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Dual-tasking, temporal embedding or having fun: When does time fly?

Vilches-Montero, Sonia

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**Dual-tasking, temporal embedding or having fun:
When does time fly?**

Presented by

Sonia Noemi Vilches-Montero

**Thesis submitted in partial fulfilment of the requirements of the degree of
Doctor of Philosophy (with coursework component)
Discipline of Marketing**

**Faculty of Business, Bond University
Queensland, Australia**

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ABSTRACT

Time is a major variable of interest to consumer behaviour theory. However, the debate regarding how to conceptualize and theorize time in consumer research still remains unsolved and a “lack of theoretical development” in the discipline has been acknowledged (Bettany & Gatrell, 2009).

Using two experimental studies, this dissertation moves into an exploration of the “*neural-clock model*” according to which individuals are expected to generate a decision about the passage of time based on the amount of interval-filling information available in memory. Taken together, findings from these two studies show that subjective time deviates from real time, and time perception is significantly affected by active information processing, time delay and stimulus’ level of enjoyment.

Most important, findings provide evidence for theoretical discussions and new research avenues. Time perception for events past is significantly distorted when subjects are cued to reconstruct and estimate the experience as a whole, as opposed to retrieving and estimating its different subparts. Both studies illustrate that in time perception “the whole is not equal to the sum of its parts”, and this effect is enhanced when duration estimates are produced after a time delay and when subjects perform active stimulus information processing. This is an interesting finding because it provides support for the application of literature in event structure and memory psychophysics regarding reconstruction of physical objects and events into time perception research. Thus, findings show that time perception seems to depend on how individuals reconstruct the experience, and not only on the amount of information stored in memory, as the neural-clock model proposes.

We know that misestimating time has profound ramifications on consumer behaviour, and marketing researchers have dedicated considerable effort to understanding the effects that time perceptions play in consumers’ decision-making. However, very little is known regarding how marketers may distort the subjective experience of time to their own benefit. This dissertation attempts to fill that gap.

STATEMENT OF ORIGINALITY

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy. This thesis represents my own original work towards this research degree and contains no material which has been previously submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

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My times are in thy hand
Psalm 31:15

I want to give thanks to God my Heavenly Father. *The God who is feeding me from my being unto this day (Genesis 48:15)*. He owns all my ways. Praised be the Lord.

I want to thank my husband Renzo and my children Catalina and Daniel for their love and commitment. Waiting for mum to come home and watching mum working late has become your speciality all these years, and you never complained.

I want to give thanks to my mother and sister for their inexhaustible provision of love and care. No daughter has had a better mum.

I want to thank my friends Ian, Sue, Daniel, Crystal and Allison for being our family in Australia. So many good memories!

I want to thank my supervisor Dr. Mark Spence for being my counsellor and mentor. What a fascinating topic of research this has been. I have fully enjoyed it. You suggested it, you made me love it, and now I do not want to give it up!

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CHAPTER 1

TIME AND TIME PERCEPTION IN CONSUMER BEHAVIOUR

“Time is too slow for those who wait, too swift for those who fear, too long for those who grieve, too short for those who rejoice, but for those who love, time is eternity”.

Henry Van Dyke

1.1 The time perception concept

Time is the dimension that transcends all human phenomena and is basic to the construction of every scenario (Graham, 1981; Hawes, 1980). Time has unique characteristics. Unlike an object which can be revisited, passed time cannot (Zacks and Tversky, 2001). Time is the only resource that nobody can accumulate or store (Hayden, 1987). In the Newtonian view time is objective, chronological, unidirectional and perpetual, characteristics that have been referred to as “the universality of time” (Benabou, 1999; Conte *et al*, 1999; Zimbardo and Boyd, 1999). In this view time is perfectly homogeneously distributed: for everyone everywhere, time passes at the same tempo all day long.

However, the subjective perception of the passage of time is prone to deviate from objective chronological time. Why does waiting in line seem so long? Why does time fly when having fun? These apparent illusions in which the speed of time changes as individuals switch from one experience to other affect individuals’ duration-estimates, either shortening or lengthening them relative to objective time. To study this phenomenon, psychologists coined the term “time perception”, which refers to the subjective experience of the passage of time (Fraisse, 1984; Hornik, 1984).

1.2 Time perception in consumer behaviour

The relevance of time and time perception to consumer behaviour theory is widely acknowledged and considered to be a major variable to consumers' decision-making processes (Baker and Cameron, 1996; Bergadaa, 1990; Graham, 1981; Jacoby *et al.*, 1976). Misestimating time, whether prospectively ("how long have I been doing this activity?") or retrospectively ("how long did that take?") has profound ramifications on consumer behaviour. Time is, after all, one of the three things -along with effort and money- that a consumer can give up in a transaction. Time perceptions act as individuals' cognitive frames that they use in forming their expectations and goals (Zimbardo and Boyd, 1999), defining their priorities (Graham, 1981), deciding on the amount and nature of the information searched (Jacoby *et al.*, 1976), prompting cognitive, emotional and behavioural responses (Baker and Cameron, 1996; Bergadaa, 1990; Bettman, 1970; Hall, 1983) as well as affecting satisfaction judgements (Katz *et al.*, 1991). Perceptions of extended versus temporary usage of products is an input to purchase decisions (Pocheptsova *et al.*, 2008); and perceptions of proximity to sales deadlines affect consumers evaluations and decisions about responding to the deadline (Swain *et al.*, 2006; Inman *et al.*, 1994). Time perceptions not only affect the nature of individuals' immediate responses, but also their further decisions on the use of time in terms of how it is scheduled, allocated and consumed (Bates *et al.*, 2006; Carman, 1970; Guy, 1994; Jacoby *et al.*, 1976).

But what precisely causes subjective time to deviate from clock time is still subject to debate. Filling-in time for someone standing in a queue (e.g., offering audio or visual stimuli) can reduce the overestimation of waiting time, which directly affects satisfaction judgments (Antonides *et al.*, 2002; Bailey and Areni, 2006; Billington and

Skinner, 2006; Gorn et al., 2004; Hui and Tse, 1996; Jones and Peppiat, 1996; Katz *et al.*, 1991). Recent psychology-based works that have consumer-related implications include exploring the intersection of time and emotions. Fear slows the perception of time passing; excitement does the opposite (Campbell and Byrant, 2007; Whitman and Paulus, 2008). Marketers can influence emotions, whether prior to, during or even after the focal time-interval. It has also been said that “time is money”. The value that we attach to it exhibits hyperbolic discounting, that is, short delays in receiving gratification receive significantly higher discount rates than is the case with long delays (Thaler, 1981). However, this effect appears to be mitigated when people consider time subjectively (Zauberman *et al.*, 2009): a delay from three to six months is perceived to be longer (hence deserves a greater discount rate) than is the same three month delay from six to nine months. People regularly make time-benefit tradeoffs, whether this means paying extra for faster delivery, deciding how long to engage in ‘search effort’ in a buying situation or determining how much pre-consumption time one is willing to endure prior to the consumption activity itself (such as standing in line or driving to location). Self-regulatory behaviour also bends time, subjectively lengthening its passage, which may cause “abandonment of further self-control” (Vohs and Schmeichel, 2003). Left unchecked, misestimating the passage of time could therefore have self-defeating effects. Ironically, over short time intervals individuals with little or no regulatory control, such as those under chemical influences like nicotine or THC, also overestimate the passage of time: short time periods seem longer (McDonald *et al.*, 2003; Carrasco and Redolat, 1998). Perhaps this influences the motivation for the next cigarette: one might think “it has been a long time since my last smoke”.

Most of the empirical work endeavouring to explicate the causes of subjective time deviating from actual clock time has occurred over the last few decades – by some

estimates there are now hundreds of studies (Grondin, 2001). A consistent conclusion is that subjective time deviates from actual clock time. The fact that memory is malleable is well accepted and therefore it should not be surprising that deviations exist. A grossly sweeping generality is that we tend to overestimate short intervals and underestimate long periods, whether retrospectively or prospectively (Brown and Stubbs, 1988; Grondin and Plourde, 2007). But why?

Marketers have skirted the study of cognitive processes underlying time perceptions, instead focusing on admittedly important consequences (e.g., fill-in time spent in queues to mitigate the displeasure of standing there). Yet, marketers can influence cognitive processes such as attention, encoding and retrieval, key mediating variables currently absent within the marketing literature when discussing time perceptions. The debate regarding how to conceptualize and theorize time in consumer research remains unsolved and a “lack of theoretical development” in the discipline has been acknowledged (Bettany & Gatrell 2009, pp. 294).

Thus, the first objective of this dissertation is contributing to fill-in this gap. The literature review examines how the concepts of time and time perception have been studied in consumer research and it encompasses both a comprehensive theoretical framework and research hypotheses. From this review, the dissertation moves into two studies designed to better understand why consumers misestimate the passage of time, which constitutes the second objective of this dissertation. It explores from various perspectives several cognitive processes underlying time-perceptions that systematically cause subjective time to deviate from actual clock time.

Implications to marketers are straightforward. In some instances marketers may wish to reduce consumers’ perceptions of elapsed times (web downloading times,

driving to location, waiting in line, etc.), while in others they may wish to increase elapsed time perceptions (park rides, holidays or leisure time). Marketers may therefore cue customers on how to perceive time to the benefit of marketers.

1.3 The structure of this dissertation

This dissertation is organized as it follows. Chapter 2 draws on the literature and advances eight research hypotheses. The neural-clock model is the starting point and has been described as a “discrete model” of time perception: individuals are assumed to estimate interval-durations based on the amount of discrete information that they store-in and recall-from memory (Areni and Grantham 2009; Bailey and Areni, 2006; Brown et al., 2007; Hee-Kyung et al., 2009; Zakay and Block 2004). Thus, it is expected that both attentional resources devoted to perceive the passage of time and memory performance will distort individuals’ duration judgements. From this view, this chapter further borrows from other streams of research on *event structure* (Zacks and Tversky, 2001) and *memory psychophysics* (Hubbard, 1994; Kerst, 1978; Petrusic and Baranski, 1998) regarding perception of physical objects and events to apply them into time perception research. Hence, it is postulated that time perception depends on how individuals reconstruct the experience, and not only on the amount of information stored in memory, as the neural-clock model proposes.

Chapter 3 addresses the traditional methodological approach to study retrospective time perceptions. Seven main methodological issues were considered and discussed in detail. The results obtained in the pre-tests are also described, which verified the

stimulus, the elicitation method to produce duration judgements and the measures for the dependent variables. Taking into consideration the results of the pre-tests and the methodological discussion, final methodological decisions for Study 1 were made. The experiment design that was chosen for Study 1 addresses the need for a better understanding of how individuals perceive time when recalling segments of an experience and producing multiple duration estimates.

Chapter 4 presents the tests conducted to examine the hypotheses that were advanced in Chapter 2. Findings from Study 1 revealed that performing active information processing (e.g., searching for information) while exposed to the stimulus distorts perceptions of time, and the duration estimate elicited for the entire series of stimuli was less accurate than the estimates produced under passive processing conditions (e.g., relaxing and watching the stimuli series). Study 1 also provided evidence for a time delay effect. Duration estimates elicited after a time delay were less accurate than duration estimates elicited immediately after stimulus exposure. The findings also illustrate that time perception for events past are less accurate if subjects are cued to reconstruct and estimate the experience as a whole, as opposed to retrieving and estimating its different subparts. Hence, Study 1 illustrates that in time perception “the whole is not equal to the sum of its parts”, and this effect is enhanced when duration estimates are produced after a time delay, when subjects are exposed to neutral rather than enjoyable events, and when subjects perform active relative to passive stimulus information processing.

Chapter 5 further explores whether longer time delays shorten duration estimates. Study 2 provides evidence for time delay effects on duration estimates of the entire series of stimuli. The longer the time delay after stimulus exposure, the shorter the

duration estimate of the entire series. It also shows that the effect of time delay on the duration estimates is greater when subjects are cued to recall and estimate the duration of the entire series of stimuli first. Thus, subjects who produced duration estimates after a long delay seemed to be less able to retrieve interval filling information and to properly reconstruct the experience. On the other hand, subjects produced more accurate estimates for the entire experience after having retrieved its different subparts. This is an interesting result because it provides support for the presence of cueing effects during experience reconstruction. Subjects overestimate the duration of the entire series when they were cued to recall its four segments first.

Chapter 6 summarizes findings from studies 1 and 2 and discusses their main research implications. Time perceptions for events past are significantly distorted when subjects are cued to reconstruct and estimate the experience as a whole, as opposed to retrieving and estimating its different subparts. Both studies illustrate that in time perception “the whole is not equal to the sum of its parts”, and this effect is enhanced when duration estimates are produced after a time delay and when subjects perform active stimulus information processing. This is an interesting finding because it shows that literature in event structure and memory psychophysics regarding perception of physical objects and events can be applied to time perception research. Thus, findings show that time perception seems to depend on how individuals reconstruct the experience, and not only on the amount of information stored in memory as the neural-clock model proposes.

Finally, Chapter 7 advances conclusions and proposes avenues for further research. The main conclusion of this dissertation is that predicating time perception solely on the neural-clock model ignores other elements inherent to the complexity of

time, such as the event reconstruction technique that individuals use to structure the information that they retrieve from memory. This chapter draws on the psychology literature on event structure to explore how this knowledge can be applied to the study of time perception. It proposes two alternative explanations to misestimating time.

First, the event-hierarchy explanation proposes that time perceptions are affected by the strategies that individuals use to construct events. Individuals are expected to produce fewer but more abstract subparts when induced to perform top-down processing. On the other hand, individuals are expected to produce more concrete subparts when using a bottom-up technique. Thus, future research could examine if time perception of a target interval is shorter when performing a top-down relative to a bottom-up event-construction.

Second, the temporal-distance explanation for misestimating time would suggest that time perceptions are likely to be biased by the temporal remoteness of the event from present. Events taking place in the far future or in the distant past are better described in terms of abstract and thematic information which more likely leads to underestimation. However, events placed near to present can be more richly described using concrete information and individuals are more likely to overestimate time.

CHAPTER 2

CONCEPTUAL OVERVIEW AND HYPOTHESES DEVELOPMENT

2.1 Introduction

How do we perceive the passage of time? Why do we misestimate real-time durations? What cognitive processes underlie individuals' time-duration judgements? Questions like these have challenged researchers for hundreds of years (Grondin, 2001). This chapter reviews the “neural-clock” model of time perception, which proposes that individuals estimate interval-durations based on the amount of discrete information that they store-in and recall-from memory (Areni and Grantham 2009; Bailey and Areni, 2006; Hee-Kyung et al., 2009; Zakay and Block 2004). From this view, this chapter further borrows from other streams of research on event structure (Zacks and Tversky, 2001) and memory psychophysics (Hubbard, 1994; Kerst, 1978; Petrusic and Baranski, 1998) regarding reconstruction of physical objects and events to apply them to time perception research. Hence, it is expected that time perception depends on how individuals reconstruct the experience, and not only on the amount of information stored in memory, as the neural-clock model proposes.

This chapter is organized as follows. In section 2.2 the neural-clock model of time perceptions is examined and its main implications to consumer-behaviour theory are discussed. From this analysis, two research hypotheses are put forward in sections 2.3 and 2.4. Drawing on event-structure literature, six research hypotheses are advanced in section 2.5 and 2.6. A discussion in section 2.7 completes the chapter, which sets the stage for the methodological approach presented in Chapter 3.

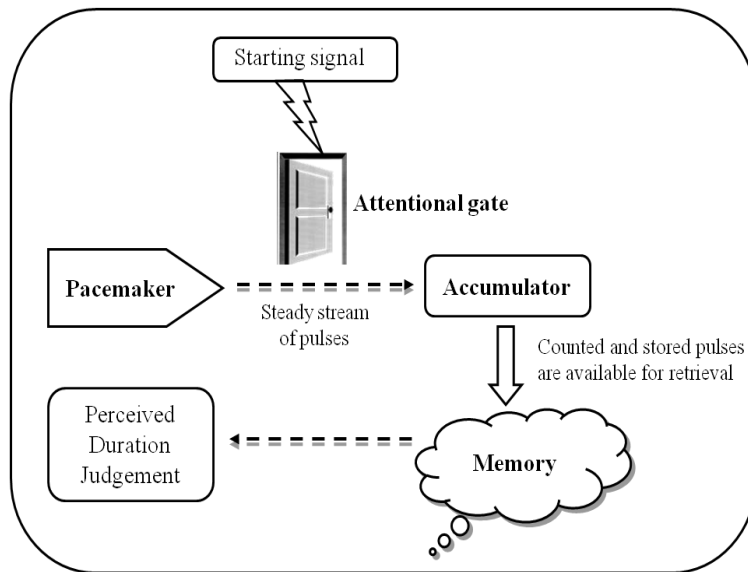
2.2 The nature of time perception: the neural-clock model

The neural mechanism relevant to time is known in the literature as the individuals' *internal clock*, *body clock* or *neural clock*, which regularly generates and accumulates pulses representing real time. A schematic representation of the neural system suggests that a *pacemaker* produces a steady stream of pulses representing real time, meanwhile an *accumulator* starts counting them at a start signal. Once the focal time-interval has ended, the accumulated number of pulses are stored in memory. As a result, the number of pulses accumulated during a given interval is the representation of its duration and individuals are expected to retrieve and use this information as a proxy to real time when making duration judgements. Thus, compared to only a few pulses being recalled, an individual who retrieves a greater number of pulses from memory is expected to produce longer duration estimates (Grondin, 2001; Mattel and Meck, 2000; Penney, Gibbon and Meck, 2000; Rammsayer and Ulrich, 2001; Staddon, 2005; Staddon and Higa 1999, 2006). Figure 1 shows a schematic representation of the neural-clock model.

According to the neural-clock model, individuals' tendency to misestimate time can be explained because of environmental stimuli which impact either the pace-maker (accelerating it or slowing it down), cognitive processes (such as attention or memory), or both. Zakay and Block (1997), for example, propose that the accumulator is updated or fed only when attention is being directed to the timing process, then opening an attentional gate: if attention is directed elsewhere, the accumulator is not updated until attention has returned. As a result, a lower number of pulses are stored in memory for retrieval and individuals tend to underestimate the passage of time. In other studies, evidence shows memory decay explains differences in duration estimates. The steady

stream of pulses generated by the pace-maker and stored by the accumulator is always available for retrieval, but memory failures prevent individuals from accurate duration judgements (Brown, 1985; Brown and Stubbs, 1988; Eisler *et al.*, 2004; Staddon, 2005; Staddon and Higa 1999, 2006).

Figure 1.
Schematic representation of the neural-clock model



Even though the literature does not explicitly define what these “pulses” consist of, and some studies prefer to use the terms “information” (Areni and Grantham 2009; Bailey and Areni, 2006), “memory markers” (Hee-Kyung et al., 2009) or “photographs” (Kundera, 1999), the neural-clock model consistently offers, throughout more than a hundred years of research, a “discrete explanation” for estimating time: longer duration judgements are associated with more interval-filling information being recalled from memory and vice versa. A nice example has been provided by Hee-Kyung et al. (2009), pp. 509:

“Imagine that last year Laurel and Hardy each went on an identical trip with family. Laurel took photographs of every family member he met and every event he participated in. Hardy did not take as many photographs. Several months later, when both men were asked to recall this otherwise unremarkable trip, they each went back to their digital photo album marked “family trip” and viewed their trip pictures as a slideshow. After viewing his 100 photographs, Laurel seemed to recall that he had a longer and more eventful trip than did Hardy who had viewed his 20 photographs”.

Thus, regardless of the terminology used, evidence consistently shows that the cognitive system produces and stores single pieces of information from real-time experiences, which are used as a cue to duration judgement.

The accuracy of the neural clock is assumed to be affected by several cognitive processes familiar to marketers, namely attention, encoding, storage and retrieval. *Attention* refers to the amount of mental effort dedicated to performing a timing task. It is doubtful readers are consciously attending to the passage of time right now, hence readers could misestimate the time spent on this task. *Encoding* is taken as the process of getting information into memory for storage. An event with non-uniform disjoints or breaks are naturally harder to discern an underlying rhythm, hence more difficult to encode. This manuscript has distinct elements (i.e., chapters, sub-headers) that are likely to be interpreted and recorded, which does serve as a crude proxy for elapsed time spent reading. *Storage* involves maintaining encoded information in memory over time. *Retrieval* involves recovering information from ones’ memory, and like other stimuli is prone to decay over time. It is reasonable to assume that you would probably be more accurate recalling how much time it took to read this manuscript immediately following its completion than you would if asked after completing other intervening tasks. Thus,

to veridically interpret the passage of time depends on subjects' ability to perform these cognitive processes.

Embracing the neural-clock paradigm, researchers have examined how cognitive processes generate temporal illusions of duration. Zakay and Block (1997), for example, found that attention is the main cognitive process underling prospective time-duration judgements (perception of time while elapsing), even above storage and retrieval; while retrospective duration-judgements (perception of times past) seem to rely upon information encoded in memory and later on, retrieved from storage. However, other researchers have found evidence to support that both prospective and retrospective duration-judgements are based on the same cognitive mechanisms and thus, the antecedents to non-veridical time-estimates may stem from any of the four cognitive processes (Eisler *et al*, 2004; Brown, 1985; Brown and Stubbs, 1988). The following two sections examine how attention and memory affect perception of times past. This sets the stage to raise the first two research hypotheses.

2.3 Attention and time perception: the role of active versus passive processing

The neural-clock model takes *attention* as the amount of mental effort devoted to perform a timing task. For short time intervals many individuals could be quite accurate at estimating elapsed time if they calmly counted, “one-thousand and one, one-thousand and two...”, hardly common nor desirable. Factors that prevent subjects from allocating the necessary attentional resources to the perception of the passage of time will result in a fewer amount of pulses stored in memory that in turn shorten individuals' duration judgements.

A common technique to force subjects to dedicate less attentional resources to the timing task is the active processing technique that was proposed by Thomas and Weaver (1975). This technique seeks to increase the subject's mental workload by asking them to perform two different tasks simultaneously (dual-tasking): a timing task and a non-temporal task, such as writing down names of capital cities, reading, solving arithmetic problems or card sorting. As a result, both concurrent temporal and non-temporal tasks compete for attentional resources from a common pool of limited mental capacity, resulting in a suboptimal level of attention being paid to the timing task (Pouthas and Perbal, 2004). Thus, a smaller number of pulses reflecting the passage of time are accumulated in the cognitive counter when the individual focuses less attention on temporal information processing, and vice versa (Zakay and Block, 2004). As a consequence, fewer pulses are available for retrieval from memory, and time estimates become more inaccurate and typically shorter. For example, customers frequently overestimate the amount of "empty-time" that they spend waiting in line, but they tend to underestimate active durations of waiting times (Hornik, 1984), a powerful insight for marketers. Moreover, the use of waiting-time fillers such as entertainment or information about the expected waiting time significantly reduces customers' overestimations of waiting times (Antonides *et al*, 2002).

Based on a review of the literature, the vast majority by psychologists, main manipulations applied to increase mental workload thereby distorting time perceptions include:

- i) Increasing level of task-difficulty. As difficulty of the non-temporal task increases, time estimate decrease (Casini and Macar, 1999; Chastain and Ferraro, 1997; Chen and O'Neill, 2001; Enns, Brehaut and Shore, 1999; Fortin, 2003;

Hemmes, Brown and Kladopoulus, 2004). Level of task-difficulty is determined by the subjects' efficacy in solving the task correctly. For instance, many experiments have successfully increased level of task difficulty using math exercises of progressing level of complexity (Enns, Brehaut and Shore, 1999).

- ii) Controlling for cueing effects. Originally proposed by Posner *et al.*, (1978) and more recently adapted by Enns, Brehaut and Shore (1999), Mattes and Ulrich (1998) and by Ulrich, Nitschke and Rammsayer (2006), this procedure consists of assessing the effect of dividing attentional resources between two concurrent timing tasks, instead of between a non-temporal and temporal task. Hence, attention is manipulated by a “pre-cue” indicating that a temporal stimulus is more likely to appear at a given spatial location within a visual setting in a series of experiments. Findings show that under cued conditions, intervals are judged to be longer than in un-cued conditions. The main explanation behind these results is that the un-cued events may attract more attention to the non-temporal information, hence the clock counter is not properly updated and consequently fewer pulses are available for timing.
- iii) Speed of stimulus processing. Researchers have proposed that temporal speed of information processing is governed by the nature of the stimulus presented during the time interval, because individuals may process much faster an expected stimulus (increased stimulus processing) relative to an unexpected one (Boltz, 1991; Jones and Boltz, 1989). Thus, prospective duration judgements of expected events are shorter than in unexpected stimulus conditions (Bundesen, 1990; Busey and Loftus, 1994; Reinitz, 1990). A different plausible explanation for these results has been offered by Ulrich, Nitschke and Rammsayer (2006), stating that

unexpected events increase level of arousal, which in turn accelerates pulses of the physical pacemaker and lengthen perceived duration of unexpected relative to expected events (see also Penton-Voak *et al.*, 1996). Interestingly, Ulrich, Nitschke and Rammsayer (2006) found empirical support for their hypothesis only for relatively long visual stimuli (Experiments 2 and 3), but not for brief ones (Experiment 1), suggesting that some time is needed before the arousal-enhancing influence on the internal pacemaker becomes effective.

More recently, researchers have acknowledged that manipulating a single, uninterrupted non-temporal task such as listening to music, file downloads, grammar-checking or puzzle-solving exercises do not represent real-life situations in which people need to judge multiple events which converge to a common experience. Taatgen *et al.*, (2007) state that the great majority of the available studies end-up in an explicit, single-shot time estimate which does not account for a wide variety of real-life scenarios where multiple events take place overtime. For example, reading this manuscript may be performed while listening to music, both of which can be interrupted by a phone call. How long did the reading task take?

Consequently, a few researchers have examined time perceptions of a series of stimuli, where subjects are asked to recall and estimate the duration of several segments of a sequential experience. For example, Brown and Stubbs (1988) studied duration judgements of four sequential music selections, each of different duration, played in four different orders. Subjects were told to just relax and listen to the recordings (passive processing). Conclusions showed retrospective timing (perceptions of time past) to be more sensitive to serial positions than prospective judgements (perception of time while elapsing), despite time estimates for each musical piece decreasing as a

function of serial position under both timing viewpoints. In simpler words, musical selections were judged longer when they were played earlier in the series and shorter when they occurred later.

Grondin and Plourde (2007) replicated the study by Brown and Stubbs (1988) by using the same range of durations, but replacing the passive task of listening to musical excerpts by active cognitive processing. As opposed to Brown and Stubbs, participants were also asked to rank the intervals durations from the shortest to the longest, to estimate the time interval of the entire session, and to estimate the duration of each task. Results showed that active processing of a series of musical selections decreased accuracy of all segment duration estimates, especially duration estimates for the first segment interval. Most interesting, there was no position effect on the retrospective estimates.

In sum, several types of dual-tasking techniques have been successful in overloading individual's cognitive attentional-resources, causing them to misestimate time. As a result, individuals are more likely to be less accurate in their estimates when performing active stimulus processing. Moreover, it seems reasonable to assume most of the day we are dual-tasking, but monitoring the passage of time is not the focal activity. Thus, if one accepts that distorting the perceived passage of time alters consumer behaviour, the effect of dual tasking in everyday contexts merits attention. The following hypothesis is therefore advanced:

H1: The retrospective duration estimate for an entire sequence of stimuli will be less accurate in active processing conditions (dual-tasking) than in passive processing conditions.

2.4 Memory and time perception: the role of time delays

Retrospective time estimation refers to individuals' assessment of a remembered duration. Consequently, past-interval estimations rely mainly on an individual's memory of what filled that time (Block, 1990; Fraisse, 1963; Ornstein, 1969; Poynter, 1983; Zakay and Block, 2004). The majority of the available literature focuses on the role of encoding and retrieval, where both cognitive processes are considered crucial for correctly retrieving the cognitive pulses that filled the elapsed time-interval. The explanation behind this is that the steady stream of pulses generated by the pace-maker and stored by the accumulator is always available for retrieval, but memory failures prevent individuals from forming accurate duration judgements (Staddon, 2005; Staddon and Higa 1999, 2006). Thus, the neural-clock paradigm proposes that individuals estimate interval durations based on the number of accumulated pulses that they can retrieve from memory.

Main approaches to examine how memory affects retrospective duration judgements are:

- i) Storage-size. Originally proposed by Ornstein (1969, 1997), this memory-based model purports remembered duration as a function of the amount of memory dedicated to store the information encountered during an event, with greater allocations of memory resulting in longer retrospective time estimates. Thus, a subject who can recall more things happening during a time interval will infer a longer elapsed time and vice versa. Hence, retrospective timing will rely more on differences in the amount of information stored in memory than on the

cognitive counter. However, support is equivocal (Block 1974, 1978; Hogan, 1975; Jankowitz, 1977; Thomas and Brown, 1974).

ii) Contextual-change. Another memory-based model for retrospective timing is the contextual-change hypothesis, according to which remembered duration judgements are based on the amount of contextual changes encoded and stored while the time interval was elapsing, and that are available for retrieval. Hence, if more contextual changes are recalled, remembered duration increases, suggesting that judged duration as a positive monotonic function of the number of contextual changes coded in memory (Block, 1989; Block and Reed, 1978).

iii) Task-switching. This is one of the preferred techniques to manipulate contextual changes. It requires participants to change two or more times the way they process a series of stimuli, usually a reading task. Task-switching is expected to produce greater segmentation of memory structures (Poynter, 1983) and to consequently increase the number of pulses recalled from memory, which in turn leads to lengthened retrospective duration-estimates. The task-switching hypothesis in retrospective timing has been empirically supported (Poynter, 1989; Zakay and Block, 2004).

iv) Syntactic-ambiguity. Other researchers have manipulated syntactic ambiguity of written sentences to increase depth of encoding. As the sentence has several possible syntactic analyses or interpretations, readers need to increase depth of processing to perform a syntactically ambiguous reading-task, which consequently increases the amount of information stored in memory. Thus, retrospective timing

increases relative to the no-syntactic-ambiguity condition (Zakay and Block, 2004).

v) Speed of the task. Pedri and Hesketh (1993) studied both the effect of the speed of the task (fast or slow) during the time to be estimated and the effect of when time estimates were obtained (immediately after the task versus following a delay). Their findings showed time estimates being shorter in the fast relative to the slow condition only when the estimates were obtained immediately after the task. In contrast, duration estimates were longer in the fast relative to the slow condition when obtained after the delay.

In sum, the storage-size hypothesis states that illusions of past durations lengthen as more interval-filling information is stored in memory. Different types of techniques have successfully increased the amount of information stored in memory: contextual changes, task switching and syntactic ambiguity.

However, most studies have elicited time estimates immediately after stimulus exposure (when subjects recall an increased amount of interval filling information), and little is known about time perceptions when subjects produce their estimates after a delay. This is another interesting insight to marketers: the effect of when individuals perform the timing task, immediately or after a delay. For example, tensions can arise when standing in a queue. How long one believed they stood in line may be different if recalling the event 24 hours later. Customers often delay taking action, such as putting off complaining or postponing a purchase after being exposed to promotional efforts. How does procrastination affect time in retrospect?

Evidence shows that time delays affect remembered durations. For example, an increased stimuli speed leads individuals to underestimate past-durations if they are produced immediately after stimuli exposure and to overestimate them after a delay (Pedri and Hesketh, 1993). In other words, once the focal interval has elapsed individuals store stimuli information in long-term memory in order to allocate cognitive resources to the completion of other intervening tasks. As a result, when subjects are asked to produce duration estimates, they need to retrieve stimuli-information from long-term memory. The fact that memory is malleable is well accepted in the literature and it is plausible to expect that memory failures will prevent individuals from forming accurate duration judgements. Thus,

***H2:** The retrospective duration estimate for an entire sequence of stimuli will be less accurate for delayed relative to immediate estimates.*

Overall, the neural-clock model can be described as a “discrete model” of time perception (Bailey and Areni, 2006). Individuals are assumed to estimate time based on the amount of discrete information that they store-in and recall-from memory. However, time is embedded in activities that people interpret and use for planning and action (Zacks and Tversky 2001). Predicating research solely on the neural-clock model ignores other constructions inherent to the complexity of time such as interpretation and structure. For example, would a past experience seem equally long if filled with five enjoyable events versus five tiresome ones? Time perceptions may also be distorted by the structure given to the information that has been recalled. For instance, estimating the time spent writing a manuscript can be done by recalling the songs listened to while

writing, by reconstructing the writing process itself, by recalling interruptions while writing, or varied combinations of them.

Thus, the next two sections draw on different streams of research on event structure (Zacks and Tversky, 2001) and memory psychophysics (Hubbard, 1994; Kerst, 1978; Petrusic and Baranski, 1998) regarding reconstruction of physical objects and events to apply them to time perception research. It is expected that time perceptions are also affected by the way subjects do structure and view discrete interval-filling information.

2.5 Time perception and event characteristics: enjoyable versus neutral times

Duration judgements may be distorted by the perceived enjoyment of the events that individuals use as a cue to duration judgements. Try to estimate how much time driving to work took you yesterday, and when doing so, think of five negative events filling the journey (e.g., getting stuck in traffic). Would your estimate be the same if you had recalled five enjoyable events instead (e.g., listening to your favourite music)? This section of the literature review attempts to test that well accepted but still not well supported axiom: “time flies when having fun” (Kellaris and Kent, 1992; Kellaris and Mantel, 1994).

Despite the powerful implications to marketers, few studies have addressed the effect of stimulus enjoyment on subjective time. Kellaris and Kent (1992), for example, studied the influence of a single musical stimulus on listeners' time perceptions. They

found that perceptions of duration are influenced by music in a way that actually contradicts the axiom: perceived duration was longest for subjects exposed to positively valenced music, and shortest for negatively valenced.

These results are consistent with Kellaris and Mantel (1994) who found that retrospective estimates were shorter for the less positive mood condition relative to the more positive one. They suggested that positively valenced music may leave more memory traces, thus expanding retrospective duration estimates. In other words, time did not fly when an interval was filled with affectively positive stimulation, a counterintuitive conclusion. Bailey and Areni (2006) found that music did affect the number of discrete music events stored in memory, but these events were not always correlated with duration estimates when individuals performed active information processing (i.e., brand recalling task).

In other studies, duration estimates have been affected by subjects' reported liking or disliking of the atmospheric music, but results are again equivocal. Some experiments have reported that time estimates decrease the more the music is liked (Cameron et al., 2003; Lopez and Malhotra, 1992) while others have found that time estimates are longer when the music is liked rather than disliked (Hui et al., 1997; Yalch and Spangenberg, 1990).

Finally, experiments using radio advertisements have manipulated level of congruity between atmospheric music and the verbal message in the ad, but results are equivocal. Time estimates are shorter when music is incongruent with the verbal material in the radio ad only when music is low in arousal (Kellaris and Mantel, 1996); but if atmospheric music is congruent with the verbal material, time estimates are longer

only when participants have limited cognitive resources available (Mantel and Kellaris, 2003).

A second perspective to the issue of time when having fun is the speed of the filling stimuli. Evidence has shown that a high relative to a slow speed of stimulus processing shortens only immediate past-interval estimates, but not the delayed ones, suggesting only a temporary effect of fast times on duration estimates (Pedri and Hesketh, 1993). Elaborating on these scarce findings, one could say that enjoyable times are usually filled with faster stimuli than are boring ones. Enjoyable times seem to create a temporary shorter illusion of duration in short-term memory, which may look different when individuals recall the event from long-term memory.

Most interesting, all previous studies cited in this section have examined the role of stimulus enjoyment for one time interval. Only a few studies have examined the effect of a series of enjoyable versus neutral stimulus on time perceptions. For example, the presence of various selections of music has been shown to reduce perceptions of waiting time relative to the waiting time condition in absence of atmospheric music (Gueguen and Jacob, 2002; Roper and Manela, 2000). Thus:

H3: The retrospective duration estimate for an entire sequence of stimuli will be less accurate for enjoyable relative to neutral stimuli.

2.6 Temporal embedding: recalling segments of an experience

Marketers can cue individuals to recall and to estimate durations for either specific segments of an experience or for the entire experience as a whole. In some circumstances estimating the whole time required to perform a task, such as commuting to work, is more important than is the duration of its several sub-parts. In other circumstances the reverse may be true, such as estimating the time (hence the cost) to complete a market research report for a client (Zimbardo and Boyd, 1999).

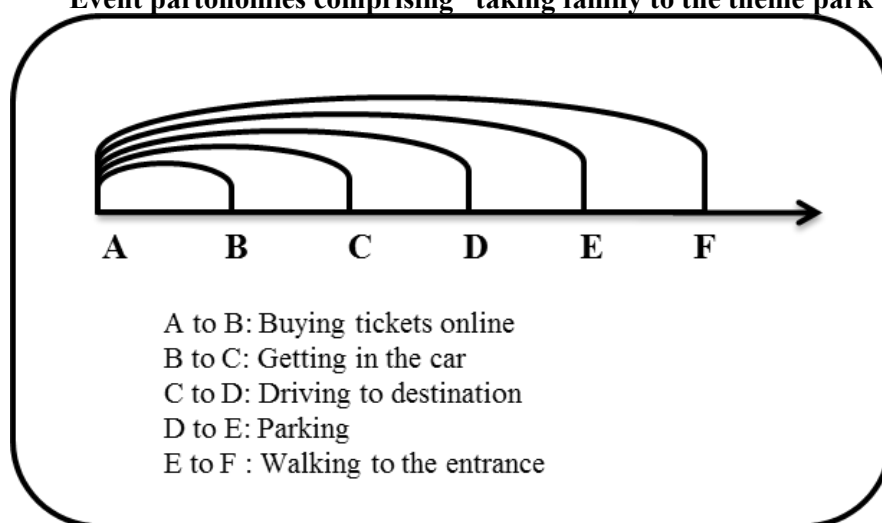
Predicating research solely on the neural-clock model ignores other constructs inherent to the complexity of time such as structure and interpretation. Time is embedded in activities that people undertake, interpret and use for planning and action (Graham 1981; Zacks and Tversky 2001). As for other perceptual processes, it is unlikely that only one factor (quantities of discrete time-filling information) can account for all biases underlying the subjective experience of the passage of time. Indeed, Poynter's (1989) memory segmentation explanation posits that duration judgements are based on remembered sequences of events combined with estimated durations of each event. Following Zacks and Tversky (2001, pp.3), an event is "a segment of time at a given location that is conceived by an observer to have a beginning and an end"; and an event's structure is taken as "the process by which observers identify these beginnings and endings and their relationships".

Perceptual psychology and sociology have examined for decades how individuals use event structure in understanding and action. The contribution of this section is to hypothesize how this knowledge can be applied to the study of time perception. In other words, it seeks to understand how the several segments of an

experience may constitute cues to duration judgements. Imagine visiting a theme park. It is full of people around and you have to wait in line before getting your children on the roller coaster. The entire experience of having the ride may be divided into two consecutive events: standing in the queue and enjoying the ride itself. If you were asked to estimate the time spent waiting in line, would your estimate differ if it were elicited right before the ride versus right after it was over?

According to Zacks and Tversky, (2001), events can be viewed as being organized in parts and sub-parts (partonomic relationships). Event partonomies look at how people segment activity as it happens. The scheme provided by Barker and Wright (1954) can be used for tracing events in a temporal continuum. Figure 2 shows how the event “taking family to the theme park” consists of sub-parts that build-up to a whole: “buying tickets online”, “getting in the car”, “driving to destination”, “parking” and “walking to the entrance”.

Figure 2.
Event partonomies comprising “taking family to the theme park”



In this case, individuals perceive events as organized into partonomic hierarchies: subordinate (i.e., getting in the car), basic (i.e., driving to destination) and superordinate (i.e., taking family to the park). Individuals tend to easily conduct bottom-up inferences when cued with subordinate-level actions, but show great trouble at making downward inferences to the subordinate level when cued with superordinate information (Abbot et al. 1985). This means that individuals tend to judge events using more subordinate rather than superordinate information. Moreover, focusing on superordinate events elicits a more abstract level of information processing compared to subordinate events (they elicit more concrete information processing).

However, research pertaining to event structure has not studied how abstractness and concreteness of information processing may affect time perception. Cueing subjects to perform top-down versus bottom-up event reconstruction techniques are expected to represent rich sources of biases to time perceptions. In other words, the event-hierarchy explanation proposed here advances that time perceptions are affected by the strategies that individuals use to reconstruct past events. Individuals are expected to produce fewer but more abstract subparts when induced to perform top-down processing and consequently to be less accurate when producing duration estimates. On the other hand, individuals are expected to produce more concrete subparts when using the bottom-up technique, and consequently to be more accurate when estimating time. Moreover, research in memory psychophysics regarding reconstruction of physical objects would suggest a non-Euclidean reconstruction: the parts do not add to the whole (Hubbard, 1994; Kerst, 1978; Newton et al. 1977; Petrusic and Baranski, 1998). In this regard, the neural-clock paradigm does not provide predictions because it does not acknowledge hierarchy in events. Thus, applying research in reconstruction of events and objects to

reconstructing time, it is expected that given a series of segments that collectively make up a whole event:

H4: *The sum of segments' estimates will not be equal to the single estimate for the entire sequence of stimuli.*

H5: *The sum of segments' estimates will be more accurate than a single duration estimate for the entire sequence of stimuli.*

H6: *The sum of segments' estimates will show lower variability compared to a single duration estimate for the entire sequence of stimuli.*

H7: *The effect of a time delay will be greater on the duration estimate for the entire sequence of stimuli than on the sum of segments' estimates.*

Another moderating factor is the serial position of the segment-interval that is being retrieved from memory. Findings concerning primacy/recency effects suggest that the first and/or last stimulus in a sequence is better remembered than those embedded in the sequence (Steiner and Rain, 1989). In this regard, time perception research actually shows that subjects are more accurate only when estimating segments that were placed early in the series (Brown *et al.*, 2000; Brown *et al.*, 2007; Collier and Logan, 2000; Estes, 1972; Farrell, 2008; Farrel and Lewandowski, 2002; Page and Norris 1998; Watkins *et al.*, 1992).

It is necessary to highlight that these studies elaborate on models of short-term memory for sequences of information. In other words, subjects produced their duration estimates immediately after stimulus exposure. Elaborating on this evidence, it is

plausible to expect individuals to be less able to retrieve information for the first and last intervals after a time delay taking place and consequently more likely to misestimate time. Thus:

H8: *The error of the duration estimate for the first and the last segment in the series will be lower than the error of the segments embedded in the series when subjects produce estimates immediately after stimuli exposure, but not when they are produced after a time delay.*

2.7 Summary

This chapter attempts to find grounds for a more explanatory and comprehensive theoretical approach to study time perceptions in consumer research. In contrast to, but not necessarily to the exclusion of the neural-clock model, it proposes that misestimating time may also be explained by how individuals reconstruct and interpret a past experience, and not only by the varied quantities of discrete information that they retrieve from memory.

First, it is expected that time perception of a target interval can be distorted by the level of enjoyment of the interval-filling information that is used as a cue to duration judgement. Despite the powerful implications to marketers, evidence on this regard is still equivocal.

Second, it is advanced that misestimating time can also be explained by the strategies that individuals use to reconstruct past events. Presenting an event as a sequence of subparts is expected to increase the amount of concrete information that

individuals use for characterizing it. In contrast, presenting an event as a whole experience is expected to decrease the amount of concrete information that individuals are able to recall. Hence, it is expected that perceived durations of all segments are not likely to add to the whole, that the sum of the segments' estimates will be more accurate and will show lower variability compared to the single duration estimate produced for the experience as a whole.

Finally, it is advanced that remoteness of an event from present affects individuals' ability to properly recall and reconstruct a past experience, which in turn affects their duration estimates. Thus, it is anticipated that time delays will more severely distort the duration estimates of the whole experience relative to the sum of the segments' estimates and will prevent subjects from producing more accurate duration estimates for the first and last segments relative to those embedded in the series.

In order to test the research hypotheses that were advanced here, the next chapter addresses a range of methodological issues and discusses their research implications. They set the stage for the methodological decisions of Study1.

CHAPTER 3

METHODOLOGICAL ISSUES CONSIDERED WHEN DESIGNING STUDY 1

3.1 Introduction

The literature review presented in Chapter 2 identified two major cognitive processes underlying retrospective time perceptions: attention and memory. It also identified the need for a better understanding of how individuals perceive time when recalling segments of an experience and producing multiple time estimates. Thus, four main research questions were outlined:

- i) How do attentional resources devoted to a series of events affect the perceived duration of the entire experience?
- ii) How does memory performance affect time perceptions when recalling series of events?
- iii) Do enjoyable series of events seem shorter in retrospect than neutral ones?
- iv) How does event reconstruction affect the perceived duration of an experience?

In order to explore these research questions, Study 1 had to consider a number of methodological issues regarding experiment design, which is the purpose of this chapter.

The first research question involves the manipulation of the amount of cognitive attentional resources that individuals can devote to monitor the passage of time. As dual-tasking is expected to consume attentional resources and distract individuals from monitoring time while elapsing, a distracting task needed to be developed that was hard enough to force participants to devote cognitive resources to performing it.

The second research question refers to the manipulation of memory performance, when individuals need to retrieve one or more events from long-term memory in order to estimate its duration. Thus, a filler-task needed to be selected in order to elicit delayed duration estimates.

The third and fourth research questions involve decisions regarding both the nature of the stimulus material and the estimates' elicitation method. A number of related methodological decisions are relevant here, such as type of experiment design (between or within subjects), dependent variables, measures and procedure, to mention but a few.

In order to address each of these methodological considerations, section 3.2 of this chapter describes the traditional methodological approaches to study retrospective time perceptions. In section 3.3, seven main methodological issues are considered and discussed. Section 3.4 presents the results obtained in the pre-tests and describes in detail the experiment design chosen for study one.

3.2 Experimental approaches used to study time perceptions

The great majority of studies on retrospective time perceptions expose subjects to only one time interval, during which they are either presented with a stimulus or asked to complete a specific task, such as listening to a radio ad or sorting cards. The experiment designs which examine the effect of attentional resources and memory decay on the subjective perception of the time spent performing this task have typically followed a two-step format (stimulus exposure and elicitation of time estimates) using a between subjects experimental design. In the first stage participants are unaware that they will be required to estimate time: when they are told to watch or listen to a stimulus or to engage in some task, they are given only a vague explanation that there will be further questions about what was seen, heard or done.

Despite the broad variety of designs used, they all seek to distort the number of “pulses” or amount of “interval filling information” that the neural system stores in and retrieves from memory. Individuals who pay less attention to perceive the passage of time and/or who retrieve little information from memory are expected to underestimate the true duration of the experience relative to individuals in the opposite scenario.

For example, when manipulating cognitive attentional resources participants in a high complexity condition complete either an ambiguous, uncued or hard task relative to participants in the control condition (low complexity). It is expected that participants in the high complexity condition will experience an increased level of mental overload and will consequently underestimate the time spent performing the task. Fasolo, Carmeci and Misuraca (2009) for instance, examine the complexity of the choice set on the perceived duration of the time spent choosing. Manipulation of task complexity was

conducted by varying the number of options available in the choice set: participants had to choose a mobile phone from a set of six different models in the low complexity condition and from 24 mobile phones in the high complexity condition. Participants having to choose 1 of 24 mobile phones tended to underestimate the time spent choosing while participants confronted with the choice of six mobile phones tended to overestimate the actual time spent.

On the other side, when a study examines the effect of memory decay on time perception, subjects in the delayed estimates condition are asked to engage in a filler task after stimulus exposure and therefore to provide delayed time-estimates, while participants in the control condition provide duration-estimates immediately after the interval has elapsed. In this case, it is expected that individuals in the delayed estimates condition will recall less information and will consequently underestimate the time spent on stimulus exposure relative to those participants in the immediate estimates condition.

Finally, only a few experiments have been conducted to study time perception of a series of events. Methodological approaches differ regarding how many events should be included in the series and which the best technique to elicit and measure duration-estimates is. Indeed, both the number of time intervals in the series and how best to measure these have been pointed out as an obstacle for the comparability of findings (Fink & Neubauer, 2001). Because of this, a number of methodological decisions had to be carefully considered during the design process of the research. The various decisions involved in designing the first experiment are considered in the following section.

3.3 Methodological considerations and decisions

Seven method related issues are reviewed in this section. Each of these methodological issues results in procedural options that could have been used in Study 1. Hence, this review clarifies in detail why Study 1 (presented in Chapter 4) was executed as it was. In this section, the seven options are first mentioned in brief and expanded afterwards into a more detailed discussion.

When designing Study 1, a decision had to be made regarding the type of experiment design, within or between subjects. This is an important decision as both designs have certain drawbacks, such as learning effects and subject variance, respectively.

A second consideration involved the type of stimuli that will be used to fill-in time. A wide variety of visual and auditory stimuli have been used in time-perception studies, however, the absence of audio-visual stimuli in the literature represents a methodological gap that is carefully examined in this section.

The third consideration refers to the number of events to be included in the series. This is important because an increased number of intervals (events) in the series may produce memory segmentation and lengthen duration estimates, an effect that might be enhanced when the clock-duration of the intervals are longer.

The fourth methodological issue is related to the best method for eliciting duration estimates and their respective measures: the methods of production, reproduction and verbal production are discussed in this section.

The fifth decision is related to the selection of dependent variables and their measures. The main methodological point of debate in this regard is the number of duration-estimates that should be elicited per participant, which is partly determined by the number of events in the stimulus series.

The sixth consideration relates to the type of distracting task that is appropriate to overload attentional resources under dual-tasking conditions. The task has to overload attentional resources enough that subjects are distracted from tracking the passage of time.

Finally, the seventh decision refers to the type of filler-task that is appropriate to affect memory performance. To be appropriate, the filler-task needs to be long and/or hard enough to force subjects to store stimuli information in long-term memory in order to complete the filler-task. Each of these design issues is now discussed in detail.

Within versus between subjects design

When designing the study, the first decision to be made concerns the type of experiment design. A within subjects design would facilitate the study of the effect of memory on time perceptions because it allows the comparison of duration-estimates which are obtained immediately after exposure to the series of stimuli with those duration-estimates elicited after completion of a filler-task (delayed estimates).

Choosing a within subjects design also eliminates the systematic bias attributable to participants in one group being different from participants in other groups (Martin, 1985). For example, in a 2x2 experiment design subjects would be asked to estimate the time-duration four times, which may result in participants becoming familiar with the time-estimation task. Moreover, after exposure to the first treatment condition, participants would be cued that the purpose of the research is related to timing, and very likely would become “wise to the game”. Learning effects would introduce a confound, whereby instead of performing worse at a third or fourth time-estimation task because of mental overload (dual-tasking) or because of memory decay (delayed time-estimates), participants may perform better.

In contrast, a between subjects design mitigates learning effect, because each subject has been randomly assigned to only one of the different treatment conditions. In this case, hypothesis testing requires an examination of the duration-estimates across conditions. The drawback of this type of design is the possibility of a subject variance effect (e.g., having different duration estimates due to subjects in one treatment condition being different from subjects in another condition). However, this can be minimized by randomly assigning subjects to each treatment condition.

Thus, taking into account that keeping subjects unaware of the timing task across all treatment conditions is absolutely necessary for the comparability of findings, a between subjects experiment design was chosen for study 1. Additionally, subjects were randomly assigned into only one treatment condition in order to minimize subject variance effects.

Stimulus

Type of stimulus material was another methodological consideration when designing Study 1. The stimulus material for duration judgement has traditionally consisted of either i) performing a specific task ii) processing visual stimuli, or iii) processing auditory stimuli.

When the stimulus consists of completing a specific task, subjects are asked to perform, for example, a card-sorting, word-spelling, arithmetic or reading task. For experiments that require a single task-duration estimate, the task is performed for a specific amount of time, which means that participants are exposed to one time-interval while performing the task. Once the task is complete (hence the time-interval has elapsed), participants are asked to produce their best estimate for the time required to complete the task (e.g., How long do you think performing this task took?). If the experiment is arranged in a series of stimuli, subjects are required to switch from one task to other two or more times. As reviewed in Chapter 2, increased task-switching is expected to increase the number of events recalled from memory, which in turn leads to lengthened retrospective duration estimates (Block, 1989; Block and Reed, 1978; Poynter, 1983, 1989; Zakay and Block, 2004).

For visual stimulus, pictures, digits or geometric patterns have mostly been used (Farrell, 2008; Gorn et al., 2004; Predebon, 1996; Tipples, 2008). In experiments that require a single task-duration estimate, subjects are exposed to a single visual stimulus. For example, in Gorn et al., (2004) subjects were asked to estimate the perceived speed of a downloading task in two different websites which differed in the hue, chroma and value of their screen colour. After 17 seconds performing the downloading task,

subjects reported greater perceived speed for the website whose colours induced more relaxed feeling states.

If the experiment is arranged in a series of stimuli, subjects are exposed to different types of visual stimuli. For example, in a study by Predebon (1996) participants were exposed to a series of geometric patterns during 48 seconds. The stimuli consisted of either 14 or 28 different geometric patterns presented individually on a computer monitor. Each form consisted of three embedded shapes presented in different size scales, and each pattern was presented for one second on the screen, at rates of approximately 3.4 and 1.7 seconds apart. Predebon's findings show that increasing the number of stimulus events shortens prospective (time-while-elapsing) and lengthens retrospective (elapsed intervals) time experiences.

For the auditory stimuli, radio ads and musical selections have been used (Bailey and Areni, 2006; Brown and Stubbs, 1998; Cameron et al., 2003; Kellaris and Mantel, 1996; Kellaris and Kent, 1992; Mantel and Kellaris, 2003). For example, some studies examined the effect of presence versus absence of atmospheric music on time perception. The presence of various selections of music has been shown to reduce perceptions of waiting time relative to the waiting time condition in absence of atmospheric music (Gueguen and Jacob, 2002; Roper and Manela, 2000).

In other experiments duration estimates have been affected by subjects' reported liking or disliking of the atmospheric music, but results are yet not conclusive: some experiments have reported that time estimates decrease the more the music is liked (Cameron et al., 2003; Lopez and Malhotra, 1992) while others have found that time

estimates are longer when the music is liked rather than disliked (Hui et al., 1997; Yalch and Spangenberg, 1990).

Finally, experiments using radio advertisements have manipulated level of congruity between atmospheric music and the verbal message in the ad. Time estimates are shorter when music is incongruent with the verbal material in the radio ad only when music is low in arousal (Kellaris and Mantel, 1996); but if atmospheric music is congruent with the verbal material, time estimates are longer only when participants have limited cognitive resources available (Mantel and Kellaris, 2003).

When designing a series of stimuli, each stimulus needs to be as discriminable as possible. For example, in the experiments conducted by Brown and Stubbs (1998), the musical selections represented subjects with very different musical styles: rock, jazz, classical and eastern.

It is also important to select stimuli which are little known to participants in order to reduce variance that might result from some stimuli being familiar to subjects while other stimuli being unknown. Evidence shows that subjects' familiarity with the stimuli may distort perceptions of time in different ways: in some experiments, time estimates are shorter when participants are exposed to familiar rather than unfamiliar music (Yalch and Spangenberg, 1993); while other experiments have reported the reverse effect: time estimates become shorter for unfamiliar compared to familiar music (Yalch and Spangenberg, 2000).

The third criterion to select type of stimulus material refers to the relevance of the stimulus in daily-life experiences. Individuals are not likely to perform arithmetic-

problem solving on a daily basis, but many of us would watch TV or listen to the radio within a normal day. To the knowledge of this author, no time perception studies have used audio-visual stimuli such as television advertisements or television shows. Thus, when designing the study, audio-visual stimuli was used because it better represent the daily-life episodes that anyone can experience within a normal day.

Number of intervals and arrangement of interval durations

Another consideration concerns the number of time-intervals which are to be presented to participants: a single time-interval (hence only one stimulus), or a series of intervals (hence a series of different stimuli).

The great majority of the studies that have tested the neural-clock model have used stimuli durations ranging from a few milliseconds up to a few minutes. Many common marketing events can be placed within this duration range, such as waiting in line, watching a range of broadcast ads, and computer start-ups or downloading files online. For example, Brown and Stubbs (1988) used a series of four musical selections: rock, jazz, classical and eastern. Each selection was of different duration (427, 344, 150 and 230 seconds, respectively) and played in four different orders. The tapes were presented to the subjects via cassette recorder; they were informed that they would hear a tape recording of four musical selections and asked to pay careful attention to the music because they would be required at the end of the procedure to answer a series of specific questions about what they had heard. Immediately after the conclusion of the tape, participants were distributed a questionnaire in which they were asked to estimate in minutes and seconds the duration of each musical selection.

When making decisions about the number of time-intervals in the series, it is also necessary to consider that the number of time-intervals could alter the entire time experience. Subjects have been shown to produce longer estimates when more events fill an entire experience (Brown and Stubbs, 1988, Poynter, 1983; Poynter, 1989; Zakay and Block, 2004). Only a small number of studies have explored time perceptions of a series of intervals, most of them have arranged 3, 4 or 5 intervals in the series (Block, 1974; Brown and Stubbs, 1988; Grondin & Plourde, 2007).

When deciding the length of the time intervals in the series, it is necessary to understand the relationship between clock interval-duration and retrospective time judgements. A small amount of studies have addressed the issue of whether longer durations lead to longer or shorter retrospective estimates relative to objective time. Some studies have reported that subjects tend to overestimate short intervals and to underestimate long ones (Brown, 1985; Block, 1974). In order to test for this effect, experiments use a series of intervals of varied lengths. For example, Brown and Stubbs (1988) arranged a series of four musical pieces in 427, 344, 150 and 230 seconds, respectively; while Grondin and Plourde (2007) arranged a series of five tasks which individuals performed during 120, 210, 300, 390 and 480 seconds, respectively.

Thus, a series of four different stimuli of varied lengths was created for Study 1. They lasted for 61, 32, 194 and 96 seconds respectively. The type of stimuli chosen is described latter in this chapter.

Method to elicit duration estimates

Three different methods have been applied to elicit and measure duration-estimates: the method of production, method of reproduction and the method of verbal estimation. Each is discussed in this section.

- i) The method of production. Participants are asked to judge the elapsed-interval duration relative to two new time-intervals. First, they are exposed to a short interval and to a long one. After this phase, participants are asked to judge whether the time spent performing the task in stage one was equal to the short interval, the long one, or somewhere in between.
- ii) The method of reproduction. Participants are asked to estimate the time spent in performing the task by producing a new and empty time interval. A “start” signal is provided when subjects start monitoring the passage of time and they provide an “end” signal when they consider that the time elapsed equals the time spent performing the task. During this process, the researcher times the clock duration of the reproduced interval, in minutes or seconds.
- iii) The method of verbal estimation. Subjects verbally indicate the time spent in performing the task during stage one, in seconds, minutes, or both.

The type of duration-judgement method that is conducted has been shown to affect the accuracy of the duration estimate. According to Brown (1985), verbally estimated durations are usually longer than the estimates obtained by the reproduction method: underestimated durations are more likely to take place when conducting

production or reproduction methods, meanwhile overestimations are more likely to be observed when using the verbal estimation method.

On the other hand, measuring duration-estimates of filled intervals by producing or reproducing empty ones would affect the internal validity of the measure: according to the “filled-duration illusion” intervals seem shorter than empty ones of the same duration (Gueguen and Jacob, 2002; Grondin and Plourde, 2007; Roper and Manela, 2000; Thomas & Brown, 1974), which would introduce a bias in the elicited estimates.

Produced durations-estimates have also been shown to be more sensitive to level of task-difficulty, a manipulation widely used to overload attentional resources. For example, Zakay & Shubb (1998), and Zakay & Block (1996) found that produced durations are strongly correlated with subjects’ ratings of subjective workload and task-performance indexes. As mental workload increases because of the task difficulty, produced duration-estimates become shorter and vice versa.

More recently, consumer researchers have proposed an adaptation of the verbal estimation method. Instead of asking participants to produce “speak-aloud” duration-estimates, they ask them to write them down in the questionnaire. This way, participants can be asked to produce several time-estimates, especially if they have been exposed to a series of stimuli. Many studies use open-ended measures to apply the method of verbal estimation (Bailey and Areni, 2006; Block, 1990; Fraisse, 1984; Kellaris and Altsech, 1992; Kellaris and Kent, 1992; Levin and Zakay, 1989; Mantel and Kellaris, 2003).

Because of the consequences that the chosen estimate-elicitation method represents for the internal validity of the measures, the adaptation of the verbal estimation method was selected for Study 1. Measuring duration-estimates of filled-intervals by producing or reproducing empty ones may affect the internal validity of the measure. Moreover, verbal estimations better represent how individuals estimate durations of past experiences in real life.

Dependent variables and measures

The next methodological consideration is related to the dependent variables and their measures. The dependent variable of all retrospective-time-perception studies is perceived duration of the time-interval(s), measured retrospectively. However, the main methodological point of debate in this regard is the number of duration-estimates that should be elicited per participant, which is partly determined by the number of events in the stimuli series. It is important to highlight that for the great majority of the experiments, subjects produce one time estimate because a single interval is the explicit focus of the study. The underlying assumption behind this methodological approach is that once the subject is asked about the duration of the time-interval, he or she is “wise to the game” because they know that the task is about timing and might monitor the passage of time, in which case estimates become prospective rather than retrospective (Brown and Stubbs, 1988).

In order to avoid this drawback, researchers have elicited past duration estimates after exposure to the entire series of stimuli is complete, so that subjects still remain unaware of the timing task while processing the stimuli. Grondin & Plourde (2007), for

example, state that the prospective findings of the traditional methodological approach are limited by the belief that it is restricted to only one judgement per participant, but it can be used “not only for several durations associated with several tasks in a given experiment, but to investigate very long intervals by the summation of tasks or even subgroups of tasks” (pp. 1311). According to Taatgen *et al*, (2007) the multiple time-estimates technique better represents the way individuals usually perceive time in real-life situations, because we are multi-tasking most of the day. They further posit that a better understanding is needed regarding how the cognitive system relevant to time perceptions works when multiple duration-estimates are required. Thus, the design of a new study should also address the methodological advantages of obtaining multiple duration-judgements from each subject, which provides a variety of information at the group and individual level.

Studies embracing the multiple-time-estimates technique widely apply open-ended measures which correspond to a slight variation of the verbal-estimation technique, because subjects are asked to write down their estimates in the questionnaire. For example, Mantel and Kellaris (2003), used the question “How long did the (radio) ad that you just heard seem to last? Please be as precise as possible, even if you are not certain”. The perceived-duration item in this case was “I estimate that the (radio) ad lasted for ____seconds” (pp. 534). Bailey and Areni (2006) also used an open-ended question, worded “without looking at your watch, please estimate how long you have been in this room” (pp. 193) and a space is provided to indicate duration-estimates in “____minutes ____ seconds”. Open-ended responses in time-perception research have also been applied by Block (1990), Fraisse (1984), Levin and Zakay (1989), Kellaris and Altsech (1992), Kellaris and Kent (1992) and Kellaris and Mantel (1996). The main

advantage of this elicitation method is that including a place for minutes and seconds prevents participants from rounding their estimates up or down, for example 3 minutes.

More recently, Grondin and Plourde (2007) asked participants to rank the duration of a series of five tasks from longest to shortest. In their experiments, participants were also asked to estimate the duration of the entire session and the duration of each task performed, in minutes and seconds. Finally, they were asked to estimate the minimum and maximum possible duration of each task. The main advantage of this approach is that it allows assessing the estimates' accuracy from different perspectives of judgement. For example, participants may be capable of judging the relative duration of tasks in retrospective from shortest to longest, but they may have great difficulty estimating their absolute duration; and by asking participants to estimate the minimum and maximum duration of a given task it is possible to assess subjects' level of confidence in their estimates, and the variability of time in the context of retrospective timing.

Because of its methodological advantages and research implications, a multiple time-estimates technique was selected for Study 1. It allows investigating how several segments' estimates may be used as cues to duration judgement for the entire event and facilitates assessing estimates' accuracy. Thus, a single duration estimate for the entire stimuli series, a duration range around this best estimate and a duration estimate for each of the four segments in the series were elicited in Study 1.

Manipulating attentional resources

To manipulate attentional resources, the criteria to select the task is that it should overload cognitive attentional-resources sufficiently enough to reduce the amount of resources devoted to perceiving the passage of time and, consequently, distorting duration-estimates. Two alternate approaches have been used: a distracting task and an information-search task.

The distracting task usually requires participants to perform either a word-spelling, colour-tracking or puzzle-solving task (Pouthas and Perbal, 2004). The intent of the distracting task is to assess the extent to which participants can monitor the passage of time while attentional resources are divided into performing dual-tasking. In this case, subjects are expected to be less engaged with processing stimulus information and to underperform the timing task relative to subjects in the passive processing condition (subjects who are told to just process stimuli information).

An alternate type of task was also considered: the information-search task, which requires participants to seek specific information within the stimuli. For example, when processing a series of audio-visual stimuli, subjects can be asked to search for stimuli-related information, such as the number of people that were shown in the advertisement. The information-search task increases level of engagement with stimulus processing and subjects are expected to experience mental overload and to have little resources available to perceiving the passage of time. As the purpose of the experiment in this research is to expose subjects to a series of four types of stimuli, the information-search task was considered more appropriate to keep subjects engaged with the stimuli.

Manipulating memory performance

The last design issue is the manipulation of memory performance, by using a filler task that allows eliciting delayed duration-estimates. The criteria to select the task is that in order to dedicate short-term memory resources to performing the filler-task, subjects are forced to store stimuli information in long-term memory. Thus, the filler task needs to be long and/or hard enough to demand serious allocation of working-memory resources to its completion. As a result, when subjects in the delayed condition are asked to produce duration estimates, they need to retrieve stimuli-information from long-term memory. A number of filler tasks meet this requirement, such as naming cities or puzzle-solving tasks. In Study 1, the selected filler task consisted of a word stem completion exercise (“name a city that begins with A___, B ___, etc.”), and lasted for one minute and 30 seconds.

Summary

A number of methodological issues need to be addressed when designing a time-perception study. The main issues refer to the type and appropriateness of the stimuli and the measures for the dependent variables. A summary of the methodological considerations discussed in this section is provided in Table 1. In light of this review, it was concluded that the experiment design for Study 1 would consist of a 2x2x2 full factorial between subjects design, using an audio-visual stimuli series of four time intervals. Stimuli would consist of four recordings representing daily-life experiences, which would elicit either enjoyable or neutral mood states. Intervals would be arranged

in varied durations. Duration estimates would be elicited by applying the method of verbal estimation through open-ended questions. The dependent variables selected for Study 1 were duration estimate for the entire experience, best duration estimate for each segment of the experience, the duration range around each best estimate, and a subjective measure of confidence in their stated time perceptions, using a seven-point scale. However, even when considering these design parameters, there were still some unanswered questions that required a round of pre-tests. These pre-tests and their findings are presented in section 3.4.

Table 1.
Summary of Methodological Considerations

	Methodological Considerations						
	Experiment Design	Stimuli	Number of Intervals in the Series	Intervals' duration	Estimates Elicitation-Method	Dependent Variables (Duration Estimates)	Measures
Options in the Literature	<ol style="list-style-type: none"> 1. Within Subjects 2. Between Subjects 	<ol style="list-style-type: none"> 1. Tasks 2. Auditory 3. Visual 	<ol style="list-style-type: none"> 1. One interval 2. Three intervals 3. Four intervals 4. Five intervals 	For studies using multiple intervals, clock durations range from 120 to 480 secs.	<ol style="list-style-type: none"> 1. Method of Production 2. Method of Reproduction 3. Verbal Estimation 	<ol style="list-style-type: none"> 1. Total experience 2. Each interval in the series 3. Ranking intervals from shortest to longest 4. Duration range 	<ol style="list-style-type: none"> 1. Start-end signals 2. Ruler 3. Open-ended questions
Comments	A within-subjects design may produce learning effects. A between subjects might lead to subjects variance.	Most of the stimuli used in the literature do not represent daily-life experiences.	Most studies expose subjects to a single interval. Arrangement of series of intervals has been little examined.	It is important to prevent strong memory-segmentation and lengthened-estimates effects.	Methods of production and reproduction have been challenged on internal validity.	Recent studies have been successful in eliciting several types of duration-estimates. It is considered to be closer to daily-life experiences.	There is no common agreement about what is the best measure.
Conclusion	Random allocation of subjects across conditions in a between subjects would prevent subjects variance while also avoiding learning effects.	No studies have exposed subjects to audio-visual stimuli, such as TV ads or TV shows.	There is a lack of understanding of how individuals recall segments of experiences to produce duration-estimates.	It is necessary to arrange intervals of varied durations within the series.	The method of verbal estimation reduces this shortcoming, because it elicits direct measures of the target interval.	Measuring several types of duration estimates allows the researcher to better examine how time-perception takes place.	It is necessary to test which measure is most suitable for the purposes of the new study.

3.4 Pre-tests to determine stimuli and measures

The objective of the pre-test was to address two remaining methodological concerns: the type of audio-visual stimuli and the measures for the dependent variables. The pre-test design, procedure and results are discussed in this section.

Choosing the audio-visual stimuli

The first pre-test helped to decide the type of audio-visual stimuli to be used in the study. The pre-test aimed to identify enjoyable and neutral videos of either television programs or television advertisements, very much like the type of marketing stimuli that anyone can experience when watching TV. Two series of four enjoyable videos and four neutral videos were pre-selected by the researcher from the public domain (e.g., YouTube <http://www.youtube.com/watch?v=YcYLQGg6-d0> ; <http://www.youtube.com/watch?v=dAQdCxG9H4w>). In order to make the stimulus series as discriminable as possible, the four videos had different durations and different themes. An effort was also made to pick little-known videos in order to eliminate variance that might result from some videos being familiar to subjects while others unknown.

For the enjoyable condition, two TV commercials and elements from two TV shows were chosen. The serial duration of each enjoyable video was 106, 64, 214 and 96 seconds. For the neutral videos, one TV commercial and the elements from three TV programs were selected. The serial duration of the neutral series of stimuli was 115, 195, 263 and 120 seconds. *In the pre-tests, these videos were shown in their entirety; for the actual experiment they were edited to match lengths.* Table 2 summarizes themes and clock durations of both series of stimuli.

Table 2.
The audio-visual stimuli in the pre-test: clock durations and themes (*)

Enjoyable Videos	Clock Duration (in seconds)	Neutral Videos	Clock Duration (in seconds)
Hidden Camera (TV show)	106	Speech (TV program)	115
Monkeys in suits (TV ad)	64	Trade Indicators (TV program)	195
Comedians (TV show)	214	Tunnel Crossing (TV program)	263
Toyota (TV ad)	96	Honda (TV ad)	120
Total Clock Duration	480		693

(*) For Study 1, videos were edited, so that their lengths were similar.

The four enjoyable videos consisted of the following, in order of presentation: the “Hidden-camera” video contained elements of a TV show in which five different people are played a joke on the street, being unaware of the fact that they are being filmed by a hidden camera; the “Monkeys in suits” video contained the full version of a TV advertisement for a job-hunting website in which a pack of cheerful monkeys dressed up in business suits deliriously celebrate what they wrongly believe to be a successful sales campaign; the “Comedians” video consisted of a selection of a TV show in which two comedians play consecutive jokes and funny magic-tricks to each other; and the “Toyota” video contained the full version of a TV car-advertisement in which a married couple wakes up in the morning and desperately race against each other for getting in the car first and drive it to work. All four videos contained upbeat background music or songs which were also congruent with the content of the videos.

The four neutral videos consisted of the following, in order of presentation: the “Speech” video contained a selection of a news television-program in which a “very important person” gives a technical speech about communication skills; the “Trading

Indicators” video also contained a selection of a news television-program in which an “expert” uses a range of financial trade-indicators to assess the performance of the economy regarding international trade; the “Tunnel-Crossing” video contained a selection of a news television-program in which the opening of a new city-tunnel is being reported, while the reporter drives through the tunnel; and the “Honda” video consisted of a car television-advertisement in which the different components and accessories of a new model are described in detail, in order to show its superior performance.

To verify the stimuli, the pre-test procedure conducted by Mantel and Kellaris (2003) was followed, as it aims to identify pleasant versus neutral musical selections. Thus, 25 subjects rated the enjoyable test-videos and 25 subjects rated the neutral test-videos on a single-item, seven-point level-of-enjoyment scale (1=Not at all enjoyable; 7=Very much enjoyable). Results are presented and discussed at the end of this section.

Testing measures for the dependent variables

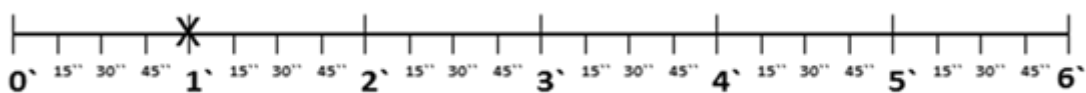
The second objective of the pre-test was to verify the appropriate measures for the time-perception estimates. For the estimate of the clock duration of the four videos taken together, for the duration-estimate of each video considered individually as well as for the duration-range around the best estimate (objective confidence-measure), both a “ruler” and a “table” were created.

As shown in Figure 3, the ruler consisted of a straight line, along which six minutes were proportionally distributed and separated by marks representing 15, 30 and

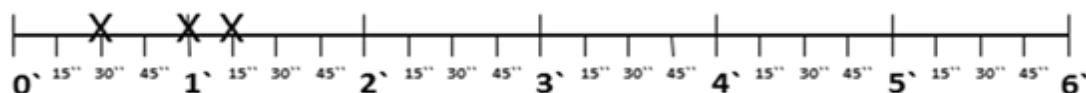
45 seconds. When using the ruler, participants were asked to write an X on top of the figure that represented their best duration-estimate in minutes and seconds. They were also asked to mark down the shortest and longest possible duration of the videos around their best estimate. (“You will be asked to estimate the duration of each video in minutes and seconds, and the duration range in which your estimate should be included. Use the ruler presented below to mark down your time estimates, considering minutes and seconds”). An example was provided in the questionnaire to explain how to complete the task. Subjects were explicitly told that they were allowed to choose any position they wanted on the ruler, and encouraged to do their best when estimating time durations. They were also encouraged to make the duration-range around the best estimate as small as possible.

Figure 3.
Testing for appropriate measures for the dependent variables: the ruler

Now you will be asked to estimate the duration of each video (in minutes, seconds) and the duration-range in which your estimate should be included. Use the ruler presented below to write down your time estimates, considering minutes and seconds. For example, if you consider that the video lasted 60 seconds, then write down an X on the ruler as shown below:



In this case 60 seconds is your best estimate. Then estimate both a lower and upper limit for your best estimate. For example, if you estimate that the shortest possible duration of the video is 30 seconds and the longest possible one is 75 seconds, then write down an X on the ruler as shown below:



When using the table, participants were asked to complete a table indicating the shortest possible duration of the video, their best estimate of how long the video took, and its longest/shortest possible duration (“Without looking back to the previous page, please write down your time estimates again, in the table presented below”). They were asked to write down their estimates in minutes and seconds by using numbers (see Figure 4).

Figure 4.
Testing for appropriate measures for the dependent variables: the table

Without looking at the previous page, please write down your time estimates again, in the table presented below. Use Numbers to represent time durations. For example, if you estimate that the first video lasted 1 minute, write 1:00 in the corresponding cell; if you consider the estimate to be 1 minute and 10 seconds write 1:10 in the cell.

	SHORTEST POSSIBLE DURATION	BEST ESTIMATE	LONGEST POSSIBLE DURATION
VIDEO 1			
VIDEO 2			
VIDEO 3			
VIDEO 4			

After completion of the duration-estimate tasks, subjects were asked to decide which type of measure was easier to understand and apply (Easier to understand: __Ruler, __ Table; Easier to apply: __ Ruler, __Table).

For the estimate of the subjective confidence about the best estimate, a seven-point scale was created. Participants were asked to express how confident they were that

the shortest and longest possible durations that they provided actually included the true duration of the video (1= Not at all confident; 7= Absolutely confident).

Procedure

Subjects were tested in two groups (enjoyable/neutral conditions) each consisting of 25 university students from a marketing lecture. They participated in the pre-test for extra-credit. Upon arrival to the auditorium equipped with comfortable chairs, computer, projector and speakers, participants were given a questionnaire and told to seat and wait for instructions.

To begin the pre-test, printed instructions on the front page of the questionnaire were read aloud by the researcher. The instructions informed them that they would be shown a series of four videos on the screen, all of them related to daily-life episodes that any of them could experience during a normal day. In order to elicit active information-processing (dual-tasking), they were advised that after seeing the videos, they would be asked to answer questions related to the main message of the videos and the sponsors that were mentioned or shown, so they should try to keep these topics in mind while watching them, in order to provide better answers in the questionnaire. They were told to not take notes regarding the videos. Subjects were not made aware of the time estimation task. The four enjoyable (or neutral) videos were then played consecutively on the screen; much like any of us would switch channels at home using a remote control.

Immediately after exposure to the stimuli, subjects were asked to answer the questionnaire. There were four questions related to the content of the videos, followed by the questions related to the duration-estimate tasks. They were first presented with the ruler, and asked to mark down a cross on top of the estimated-time position. After producing these estimates, they had to express their level of confidence that their estimate-range would actually contain the clock duration of each video. After completing this task, they were asked to re-estimate time durations in minutes and seconds and fill-in the table with estimates expressed in numbers. Finally, the last section of the questionnaire asked them to choose whether the ruler or the table was the easiest to understand and the easiest to apply. After completion of the questionnaire, students were thanked for participating and dismissed (See Appendix 1 for a full version of the questionnaires used in the pre-tests).

Results and discussion

To test for how enjoyable the two series of videos were, a t-test was conducted. Dependent variable was level of enjoyment, measured with a seven-point scale (1=Not at all enjoyable; 7=Very much enjoyable). Overall, the four enjoyable videos were rated significantly higher ($Mean_{Enjoyable} = 5.36; SD = 1.433$) than the four neutral ($Mean_{Neutral} = 2.13; SD = .991$) videos ($t = -5.488; p < .001$). Levene's Test for equality of variances showed no significant difference ($F(1,23) = .953, p = .343$).

Regarding the measures for the duration estimates, 52% of the subjects considered the ruler to be easier to understand than the table; and 58% considered the ruler to be easier to apply than the table. However, a quick review of the duration-estimates provided by participants showed that 18% of them could not use the ruler properly. Instead of producing three duration estimates per video (their best estimate, the shortest and the longest possible duration), some of them provided only two duration-estimates while others marked down four.

In addition, there was a strong tendency to round the estimates to either 15, 30 or 45 seconds: only a few subjects marked down a cross in between these marks. On the other hand, all subjects could successfully complete the table using numbers to sign out their duration-estimates: all of them produced three estimates per video and there was higher variability of estimates (e.g., 3 minutes 17 seconds). Thus, the table was considered to be a more appropriate measure to elicit multiple estimates per subject.

The subjective level of confidence on the duration-range estimate was also examined. First, the average level of confidence for the entire series was estimated by taking the mean of the level of confidence provided for each video. The test showed that confidence in estimates was significantly lower for the enjoyable videos ($Mean_{Enjoyable} = 4.25, SD = .707$) than for the neutral ones ($Mean_{Neutral} = 5.69, SD = .765$); ($t = 4.230, p < .001$). Levene's Test for equality of variances showed no significant difference ($F(1, 23) = .043; p = .838$).

Summary

In summary, the pre-test verified that both series of stimuli significantly differ in level of enjoyment and level of subjective confidence on the estimates. The subjects also showed to better understand and apply numbers to indicate their duration estimates, and a greater variability of estimates were provided when using numbers to fill the table rather than the ruler.

Taking into consideration the results of the pre-test and the methodological discussion provided in this chapter, final methodological decisions were made. The following chapter presents a detailed outline of the experiment design, the procedure and measures used in Study 1, followed by the tests conducted to examine the hypothesis that were advanced in Chapter 2.

CHAPTER 4

STUDY 1: METHODOLOGY AND FINDINGS

4.1 Introduction

From the literature review presented in Chapter 2, we know that eliciting multiple duration-estimates for a series of intervals has only compared prospective versus retrospective time perceptions, and no manipulations have been applied to test the role of attentional resources and memory on a series of events. Attentional resources and memory have only been manipulated on subjects exposed to a single time-interval. The study presented in this chapter addresses the research gaps identified in Chapter 2:

- i) How do attentional resources devoted to a series of events affect the perceived duration of the entire experience?
- ii) How does memory affect time perceptions when recalling series of events?
- iii) Do enjoyable events seem shorter in retrospect than neutral ones? and
- iv) How does event reconstruction affect the perceived duration of an experience?

The study presented consisted of a 2x2x2 between-subjects experimental design. Section 4.2 of this chapter presents the experiment design, procedure and measures included in Study 1. In section 4.3, hypothesis testing and findings are presented. Finally, section 4.4 discusses the general conclusions, which sets the stage for the design of Study 2.

4.2 Methodology chosen for Study 1

Study 1 consisted of a 2x2x2 between subjects design (*active/passive encoding by immediate/delayed time estimates by enjoyable/neutral videos*). Table 3 outlines the eight treatment conditions. Each subject was exposed to one type of audiovisual stimuli, either enjoyable or neutral videos. Because order effect is not the focal objective of the research, the sequential order of the videos was not counterbalanced in this study. Thus, the collection of four videos was presented in the same order across conditions.

Table 3.
Experimental conditions in Study 1

Manipulation of Attentional Resources	Manipulation of Memory Performance	Manipulation of Stimulus Enjoyment	Treatment Conditions (Interactions)
Active Processing (Dual-tasking)	Immediate	Enjoyable	Active x Immediate x Enjoyable
	Estimates	Neutral	Active x Immediate x Neutral
	Delayed	Enjoyable	Active x Delayed x Enjoyable
	Estimates	Neutral	Active x Delayed x Neutral
Passive Processing	Immediate	Enjoyable	Passive x Immediate x Enjoyable
	Estimates	Neutral	Passive x Immediate x Neutral
	Delayed	Enjoyable	Passive x Delayed x Enjoyable
	Estimates	Neutral	Passive x Delayed x Neutral

Manipulations and stimuli

The first manipulation is related to the type of stimulus material. The audiovisual stimuli for duration judgement were two series of four videos each. Both series of either enjoyable or neutral videos were verified in the pre-test presented in Chapter 3. In order to make the stimulus series as discriminable as possible, the four videos had different durations and different themes. However, in order to ensure comparability of findings, both series of stimuli (enjoyable/neutral) were edited so that their lengths had the exact similar clock-duration: 61 seconds, 32 seconds, 194 seconds and 96 seconds as shown in Table 4 below. When the enjoyable videos were edited, a precaution was taken that cutting their content would not affect the meaningfulness of its content. The content of the videos was described in Chapter 3.

Table 4.
Arrangement of audio-visual stimuli: clock durations and themes

Enjoyable Videos	Clock Duration (in seconds)	Neutral Videos
Hidden Camera (TV show)	61	Speech (TV program)
Monkeys in Suits (TV ad)	32	Trade Indicators (TV program)
Comedians (TV show)	194	Tunnel Crossing (TV program)
Toyota (TV ad)	96	Honda (TV ad)
Total Clock Duration	383	

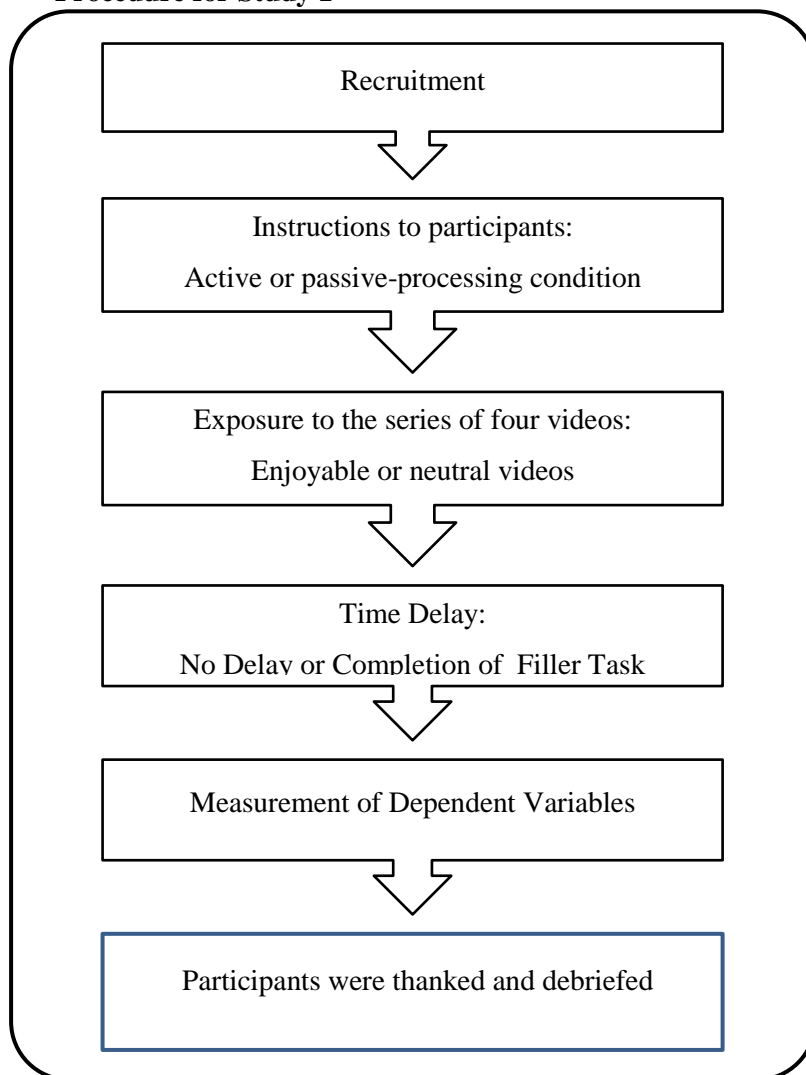
For the second manipulation, active processing was elicited by asking the subjects to search for specific information while watching the videos (dual-tasking). They were told that after watching the videos they would be asked questions either about the message and the sponsor of the videos. They were encouraged to keep these questions in mind, but were not allowed to take notes. Individuals under the passive-processing condition were told to just relax and watch the videos, much like many of us would watch TV.

For the third manipulation, subjects differed in when they were asked to provide time estimates. Immediate duration-estimates were asked for right after subjects were exposed to all four videos, while delayed estimates were provided after subjects completed a short filler task. The filler task consisted of a word stem completion exercise (i.e., Name a city that begins with A____, B ____, etc.), and lasted for one minute and thirty seconds.

Procedure

The procedure used for Study 1 followed the stages listed in Figure 5 below.

Figure 5.
Procedure for Study 1



During the recruitment stage, subjects were randomly assigned to only one of the eight experimental conditions presented in Table 3. Upon arrival to a lecture auditorium equipped with chairs, computer, projector and speakers, participants were given a questionnaire and told to sit and wait for instructions.

During the second stage, printed instructions on the front page of the questionnaire were read aloud by the researcher to all participants in the room (see Appendix 2 for a sample version of the questionnaire that was used in Study 1). To begin the study, an “Explanatory Statement” and the “General Instructions” of the study were read aloud by the researcher to all participants in the room. The explanatory statement informed them that participation in the study was entirely voluntary, and that they could withdraw at any time without penalty. They also were told that their answers would be kept anonymous, according to University Guidelines. They were provided with the study’s protocol number and contact details of the Bond University Research Ethics Committee in case they had any complaints regarding the manner in which the study was conducted.

On the second page of the questionnaire the instructions informed them that they would be shown a series of four videos on the screen, all of them related to daily-life episodes that any of them could experience during a normal day. Subjects in the active processing condition (dual-task) were encouraged to pay attention to the sponsor and the message of the videos, so they would be able to provide better answers to the questions after stimulus exposure. Subjects in the passive processing condition were told to just relax and enjoy the videos. No subjects were aware of the time-estimation task.

During exposure to the audiovisual stimuli, the four enjoyable (or the four neutral) videos were then played consecutively on the screen, like many of us would switch channels at home using a remote control.

Immediately after watching the stimuli, subjects were asked to answer the questions. For participants in the immediate estimates condition (no delay), the first three questions were related to the content of the videos, followed by the questions related to the duration estimate tasks. Participants in the delayed estimates condition had to answer the same three questions related to the content of the videos, plus the filler task, which lasted for one minute and thirty seconds.

In order to measure the dependent variables, participants in all eight conditions were asked to write their time estimates in minutes and seconds by using numbers and completing the table provided in the questionnaire (see Figure 3 in Chapter 3). After producing these estimates, they had to express their level of confidence that their estimate range would actually contain the clock duration of each video.

Finally, they were asked to estimate the duration of the entire series and to answer questions related to the manipulation checks.

After completion of the questionnaire, students were thanked for participating and dismissed.

Measures

After exposure to the stimuli series, subjects were asked to estimate the duration of each video (best estimate), and the briefest and longest duration-range that should encompass their best estimate. They were told to “*estimate the duration of each video in minutes and seconds*” and to put a range about that estimate: “*what is the shortest time the video could have lasted and what is the longest time?*” They also had to express their level of confidence that the range estimate would actually contain their best estimate by using a seven-point Likert scale. The former is an objective measure of confidence and the latter is subjective (Spence and Brucks, 1997). After answering questions related to the content of the videos they were asked to estimate the total time-duration of the four videos taken together.

Subjects

A total of 240 university students aged from 18-30 years old volunteered for the study for course credit-points. Because the students received extra credit for participating, they were asked to provide their names on a separate paper sheet, but their names were not connected to their answer sheet, hence anonymity was guaranteed. Participants were allowed to discontinue the study at any time, if desired. The final sample size was 210 subjects, who completed the questionnaire.

Manipulation checks

The last section of the questionnaire was dedicated to the manipulation checks. To check for enjoyable versus neutral stimuli, subjects were asked: “Overall, how enjoyable were the four videos?” and then asked to use a seven-point scale to rate how enjoyable the videos were (1= Not at all enjoyable; 7= Very much enjoyable).

To check for attentional resources and memory decay, participants were asked to express level of agreement or disagreement with the statements “I paid very careful attention to the videos when they were being played” and “I can remember lots of details in the videos”, respectively. They were asked to mark down their preference on a seven-point scale (1= Strongly disagree, 7= Strongly agree). Table 5 summarizes all methodological decisions that were used for Study 1.

Table 5.
Summary of methodological decisions for Study 1

	Methodological Considerations						
	Experiment Design	Stimuli	Number of Intervals in the Series	Intervals' duration	Estimates Elicitation-Method	Dependent Variables (Duration Estimates)	Measures
Options in the Literature	<p>Within Subjects</p> <p>✓ Between Subjects</p>	<p>Tasks</p> <p>Auditory</p> <p>Visual</p> <p>✓ Audio-Visual</p>	<p>One interval</p> <p>Three intervals</p> <p>✓ Four intervals</p> <p>Five intervals</p>	<p>Studies using series of interval durations range from 120 to 480 seconds.</p>	<p>Method of Production</p> <p>Method of Reproduction</p> <p>✓ Verbal Estimation</p>	<p>✓ Total experience</p> <p>✓ Each interval in the series</p> <p>✓ Duration range</p> <p>✓ Subjective Confidence</p>	<p>Start-end signals</p> <p>Ruler</p> <p>✓ Open-ended questions</p>
What was used in Study 1	<p>A 2x2x2 between-subjects experimental design was arranged.</p>	<p>There were two series of stimuli: enjoyable versus neutral videos. They contained elements of TV ads and TV shows. All videos were verified in the pre-test presented in Chapter 3.</p>	<p>Four intervals were selected and allocated a different video type. There were two series of four videos each: enjoyable and not-enjoyable videos.</p>	<p>The selected durations are discriminable and also prevent subjects from rounding up or down their estimates. (61, 32, 194 and 96 secs).</p>	<p>The method of verbal estimation was adapted according to previous studies that ask participants to write their duration-estimates down in a questionnaire.</p>	<p>Variables Measured in study 1 were:</p> <p>✓ Duration of the four videos taken together.</p> <p>✓ Duration of each video in the series</p> <p>✓ The shortest and longest possible duration of each video in the series</p> <p>✓ Level of confidence that the duration-range contains the actual duration of each video.</p>	<p>All variables were measured by using open-ended questions, according to results obtained in the pre-test presented in Chapter 3.</p>

4.3 Hypotheses tests and findings

Manipulation checks were analysed first to verify that i) both series of stimuli significantly differed in level of enjoyment, ii) to ensure that the active processing condition was, in fact, consuming attentional resources and iii) to check for memory performance in the delayed estimates condition, as opposed to the immediate estimates condition. After this, hypothesis testing was conducted and a discussion of the main findings was also outlined.

Manipulation checks

A manipulation check was carried out on both series of stimuli to test for level of enjoyment. This was measured in the questionnaire using a seven-point scale (1= Not at all enjoyable; 7= Very much enjoyable). The t-test showed that subjects in the enjoyable condition rated the series of videos significantly higher ($Mean_{Enjoyable} = 5.580$, $SD = 1.045$) than individuals in the neutral ($Mean_{Neutral} = 3.326$, $SD = 1.368$) condition. This difference is significant at $p < .001$ ($t = 13.504$). Levene's test showed unequal variances ($F(1,208) = 13.124$, $p < .001$). However, the alternate t-value under conditions of inequality of variances shows that the difference is still significant at $p < .001$. Thus, the manipulation was successful: results show that the series of enjoyable videos were rated significantly higher than the series of four neutral videos.

A second manipulation check was conducted to verify if active versus passive processing conditions affected attentional resources. When watching the videos, participants in the active processing condition were asked to search for specific

information, while participants in the passive-processing condition were asked to just relax and watch the videos.

Active processing is expected to cause individuals' to dedicate more cognitive resources to processing the stimuli, so that they have less resources available to pay attention to the passage of time. This was measured in the questionnaire by using the statement "I paid a lot of attention to the videos", followed by a seven-point scale (1= Strongly Disagree; 7= Strongly Agree). Results show that self-reported level of attention paid to the videos did not significantly differ ($t = -1.235$; $p > .10$) between subjects in the passive processing condition ($Mean_{Passive Processing} = 4.71$; $SD = 1.396$) and individuals in the active-processing condition ($Mean_{Active Processing} = 4.94$; $SD = 1.348$). Levene's test for equality of variance showed no significant difference ($F(1, 208) = 1.697$; $p > .10$). This self-reported level of attention paid to the videos was not affected by dual-tasking as desired: searching for different types of information while watching the videos did not elicit a higher level of attention compared to just relaxing while watching them. This might cause problems when testing for H1.

The third manipulation check was conducted to test for memory performance. When providing duration estimates, individuals in the immediate estimates condition produced their estimates immediately after being exposed to the videos, while individuals in the delayed condition produced their estimates after completing a filler task. This filler task is expected to cause individuals to store stimuli information in long term memory, so that they experience memory decay when recalling information related to the videos. In the questionnaire, this was measured by using the statement "I can remember lots of details from the videos" followed by a seven-point scale (1= Strongly

Disagree; 7= Strongly Agree). The t-test showed that memory decayed after subjects completed the filler task. Individuals' self-reported memory for stimuli information was significantly higher in the immediate estimates condition ($Mean_{Immediate\ Estimates} = 4.68; SD = 1.308$) relative to the delayed-estimates ($Mean_{Delayed\ Estimates} = 4.18; SD = 1.516$) condition ($t = 2.562; p < .001$). Levene's test showed equal variances ($F(1,208) = 2.729; p > .10$). Thus, the manipulation was successful: results for self-reported memory performance show that completion of the filler task caused memory decay.

Hypothesis testing

The hypotheses developed in Chapter 2 involve two dependent variables: the duration estimate for the entire series of videos (DES) and the sum of the duration estimate of each video (SSE) or “sum of the parts”. Hypothesis testing is conducted and presented in this section according to the type of dependent variable which is involved.

i) Dependent variable: duration estimate for the entire series (DES)

The duration estimate for the entire series (DES) was measured by asking the subjects: “Taken together, how long do you think the four videos lasted?” Subjects provided estimates in minutes and seconds, which were transferred into their equivalent amount in seconds when creating the database (e.g., 1 minute and 30 seconds = 90 seconds). According to Chapter 2, the main cognitive processes that distort time perceptions of single intervals are attention and memory. In Study 1, it is expected that the same factors will distort perceptions of the total duration of a series of intervals.

The three hypotheses which involved this dependent variable in Chapter 2 were:

H1: *The retrospective duration estimate for an entire sequence of stimuli will be less accurate in active processing conditions than in passive processing conditions.*

H2: *The retrospective duration estimate for an entire sequence of stimuli will be less accurate for delayed relative to immediate estimates.*

H3: *The retrospective duration estimate for an entire sequence of stimuli will be less accurate for enjoyable relative to neutral stimuli.*

These hypotheses were tested by examining whether there is a main effect for the three main manipulations outlined in Study 1. First, ANOVA assumptions were tested. These two main assumptions are population normality and homogeneity of variance (Hair et al., 2006). If either is violated, some correcting techniques may be necessary.

In order to test for homogeneity of variance, a Levene's test of equality of variances was conducted, which tests the null hypothesis that the variance of the dependent variable is equal across groups. Violations of this assumption distort the shape of the F-distribution so that the critical F-value no longer corresponds to a cut-off criterion of .05. Levene's test showed that the homogeneity of variance assumption was not violated ($F(7, 202) = .933; p = .482$).

In order to test for population normality, a Kolmogorov-Smirnov test was conducted. The test showed that normality of the dependent variable cannot be assumed ($KS(210) = .093$; $p < .001$). Table 6 shows the presence of extreme values over 2 standard deviations. Thus, it was necessary to check whether they constitute outliers in the model and if they do how the model is affected by them and what transformations can be applied to resolve the non-normality issue.

Table 6.
Extreme values over 2 standard deviations

	Case Number	Estimate (in seconds)
Highest extremes	80	1210
	106	1210
	72	1203
	179	1200
	150	1020
Lowest extremes	190	80
	61	120
	149	140
	199	150
	147	150*

* Only partial lists of cases with the value 150 are shown in the table of lower extremes.

When checking for outliers, the multiple regression technique was applied (Hair et al., 2006), which defines an outlier as the observation that has a substantial difference between the actual value for the dependent variable and the predicted value and thus considered to be inappropriate representation of the population from which the sample is drawn. In order to run a multiple regression model, the three independent variables of the study (attention, memory and enjoyment) were taken as dummy variables (e.g., active processing= 1; passive processing = 0).

The difference or distance between observations and predicted values was calculated using the “Difference in Fit” (DFFIT) technique (Hair et al., 2006). The equation for the regression model is presented below.

$$(1) \quad DES = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

Where:

DES= Duration Estimate for the Entire Series

β_0 = *Intercept*

β_1 = *Slope for task condition*

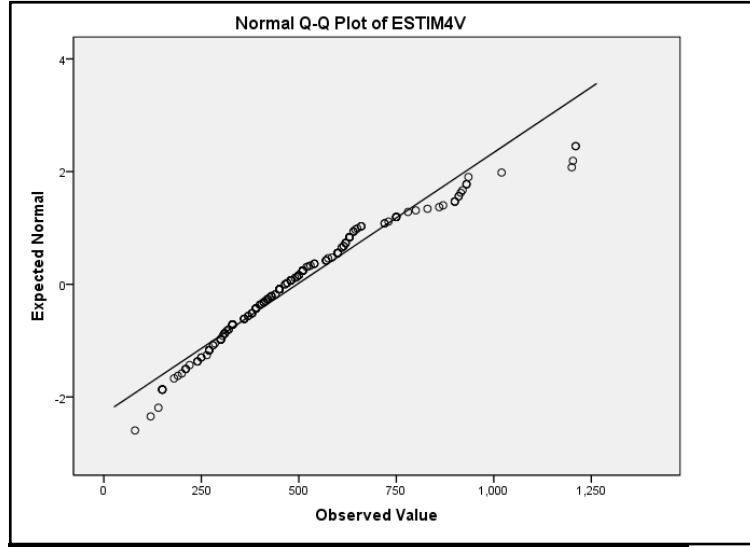
β_2 = *Slope for time condition*

β_3 = *Slope for stimuli enjoyment*

Figure 6 plots the regression model for equation (1). The “Difference in Fit” (DFFIT) statistics technique calculates distances between the expected (or predicted) values and the actual observations and indicates whether the beta coefficients are sensitive to the presence of outliers. According to Figure 6, most of the prospective outliers correspond to observations over 1,000 seconds and less than 200 seconds, respectively.

As the plot shows the presence of outliers, the Standardized DFFIT beta values were estimated for each data point in order to identify which exact observations constitute outliers.

Figure 6.
Identification of outliers: OLS solution



According to the DFFIT technique, a data point is considered to be an outlier that affects the significance of its respective beta coefficient if:

$$|Std. DFFIT \beta_i| > \sqrt{3/n}$$

In this case, sample size n is 210, then $\sqrt{3/n} = .207$. Thus, a data point is considered to be an outlier if:

$$|Std. DF \beta_i| > .207$$

As shown in Table 7, some data points are multivariate outliers. For example, estimates produced by subject 80 affected the significance of B0, B1, B2 and B3 simultaneously. Consistent with Hair et al., (2006), all data points in Table 7 were replaced by their predicted value.

After this transformation was conducted, both normality and homogeneity of variance could be assumed. The Kolmogorov-Smirnov test for normality of the dependent variable was $KS(198) = .057$; $\rho = .200$ and the Levene's test of equality of error variances was $F(7, 202) = 1.302$; $\rho = .251$.

Table 7.
Identification of outliers (DFFIT technique)

B0		B1		B2		B3	
Subject	DFFIT values	Subject	DFFIT values	Subject	DFFIT values	Subject	DFFIT Values
114	0.29849	80	0.24354	80	0.26612	72	0.26169
202	0.29849	106	0.23741	72	0.25842	80	0.24847
120	0.29191	179	0.22848	150	0.24194	179	0.23669
203	0.27219	72	-0.21163	106	-0.21596	106	-0.23347
106	0.21853	86	-0.22044				
80	-0.25042						

After ANOVA assumptions were tested and outliers replaced, the ANOVA tests were conducted in order to examine the main effects for the three main manipulations outlined in Study 1. Tables 8.a and 8.b present the ANOVA tests and its descriptive statistics, respectively.

Table 8a.
ANOVA Tests of between-subjects effects (2x2x2 factorial design)
Dependent variable: DES (duration estimate for the entire series)

Source	Sum of Squares	Df	Mean Square	F	Sig.	One-tailed Sig.
Task condition	162243.801	1	162243.801	3.585		.030
Time condition	93357.491	1	93357.491	2.945		.044
Enjoyment	51186.285	1	51186.285	1.131		.145
Task condition *	23685.365	1	23685.365	.523	.470	
Time condition						
Task condition *	236054.899	1	236054.899	5.216	.023	
Enjoyment						
Time condition *	148387.143	1	148387.143	3.279	.072	
Enjoyment						
Task condition * Time	2544.224	1	2544.224	.056	.813	
condition * Enjoyment						
Error	9141031.473	202	45252.631			

Table 8b.
Descriptive statistics for ANOVA tests
Dependent variable: DES (duration estimate for the entire series)

Task Condition	Time Condition	Enjoyment Condition	Mean (in seconds)	Std. Deviation	Sample Size
Passive Processing	Immediate Estimates	Enjoyable	504.33	212.423	30
		Neutral	421.30	198.904	27
		Total	465.00	208.532	57
	Delayed Estimates	Enjoyable	478.75	150.620	28
		Neutral	489.25	243.101	24
		Total	483.60	196.699	52
	Total	Enjoyable	491.98	184.038	58
		Neutral	453.27	221.204	51
		Total	473.87	202.252	109
Active Processing	Immediate Estimates	Enjoyable	478.28	240.295	29
		Neutral	516.90	207.103	29
		Total	497.59	223.189	58
	Delayed Estimates	Enjoyable	481.60	199.654	25
		Neutral	641.94	249.424	18
		Total	548.72	233.164	43
	Total	Enjoyable	479.81	220.360	54
		Neutral	564.79	229.946	47
		Total	519.36	227.756	101
Total	Immediate Estimates	Enjoyable	491.53	224.966	59
		Neutral	470.80	207.030	56
		Total	481.43	215.722	115
	Delayed Estimates	Enjoyable	480.09	173.722	53
		Neutral	554.69	254.553	42
		Total	513.07	225.278	95
	Total	Enjoyable	486.12	201.533	112
		Neutral	506.76	231.155	98
		Total	495.75	215.584	210

The output in Tables 8.a and 8.b shows a significant main effect for task condition

($Mean_{Passive\ Processing} = 473.87$, $Mean_{Active\ Processing} = 519.36$, $F(1, 202) = 3.585$; one – tailed $p = .030$) and a significant effect for the time

condition($Mean_{Immediate} = 481.43$, $Mean_{Delayed} = 513.07$, $F(1, 202) = 2.945$; *one – tailed* $p = .044$) in the hypothesized direction: the actual clock time of the stimulus series was 383 seconds, hence means closer to 383 are more accurate. However, the output shows no significant effect for the enjoyment condition($Mean_{Enjoyable} = 486.12$, $Mean_{Neutral} = 506.76$, $F(1, 202) = 1.131$; *one – tailed* $p = .145$). Hence there is support for hypotheses 1 and 2, but not for hypothesis 3.

The output also showed a significant interaction effect for task condition by enjoyment ($F(1, 202) = 5.216$; $p = .023$). That is, the influence of the task condition (active/passive processing) on the total duration estimate depends on the video type (enjoyable/neutral). For the significant interaction effect (task condition*enjoyment), a simple effects analysis was conducted. Paired comparisons for equality of mean appear in Table 9 and are depicted in Figure 7.

Figure 7.
Interaction effect (task condition by enjoyment)

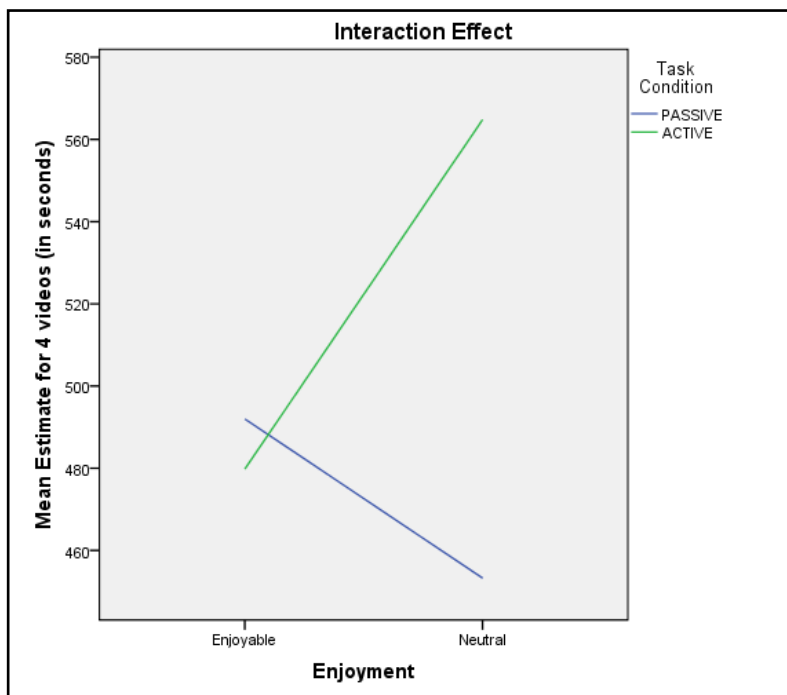


Figure 7 shows that subjects exposed to the neutral videos under active processing produce the highest (and least accurate) duration estimate ($Mean_{Neutral, Active} = 564.79$). On the other hand, subjects under passive processing conditions produce the lowest (and most accurate) total duration estimate ($Mean_{Neutral, Passive} = 453.27$). As shown in Table 9, this difference is significant at $\rho < .016, (t = -2.446)$.

Table 9 also shows that subjects exposed to the enjoyable videos do not significantly differ in their duration estimates in active ($Mean_{Enjoyable, Active} = 479.81$) relative to passive ($Mean_{Enjoyable, Passive} = 491.98$) treatment conditions ($t = .318; \rho = .880$).

Table 9.
Interaction effects analysis: descriptive and t-tests for equality of means

Source	Condition	Mean	Sample Size	St. Dev.	t-score	Df.	Sig.	Levene's Test
Enjoyable	Active Processing	479.81	54	220.360	.318	110	.880	F(1,110) = 1.966
	Passive Processing	491.98	58	184.038				$\rho = .164$
Neutral	Active Processing	564.79	47	229.946	-2.446	96	.016	F(1, 96) = .017
	Passive Processing	453.27	51	221.204				$\rho = .898$
Active Processing	Enjoyable	479.81	54	220.360	1.894	99	.061	F(1, 99) = .142
	Neutral	564.79	47	229.946				$\rho = .707$
Passive Processing	Enjoyable	491.98	58	184.038	.997	107	.321	F(1,107) = 1.087
	Neutral	453.27	51	221.204				$\rho = .300$

For the active-processing condition, subjects exposed to the enjoyable videos do not differ from subjects exposed to the neutral videos ($Mean_{Active, Neutral} = 564.79; Mean_{Active, Enjoyable} = 479.81; \rho = .061$).

Finally, Table 9 shows that for subjects in passive-processing conditions, duration estimates do not differ across enjoyable ($Mean_{Passive, Enjoyable} = 491.98$) versus neutral ($Mean_{Passive, Neutral} = 453.27$) treatment conditions ($\rho = .321$).

These results can be interpreted in light of Bailey and Areni (2006) and Kellaris et al., (1996). They suggest that listening to a pleasant stimulus (such as music) may leave more memory traces. Hence, more music information is remembered which increases perceived duration. In Figure 7, the interaction effect shows that the duration estimate for the enjoyable stimuli series did not differ in passive versus active processing conditions. It is plausible to suggest that because the enjoyable videos were engaging, subjects devoted attentional resources to processing them even when they were cued to perform passive processing. Moreover, a t-test conducted to test for the self-reported level of attention paid to processing the enjoyable videos showed that there was no significant mean difference between subjects in the active versus passive processing condition

($Mean_{Enjoyable, Active} = 4.98, SD = 1.25; Mean_{Enjoyable, Passive} = 5.02, SD = 1.235; t = .152; \rho = .879$). Thus, it is plausible to suggest that cueing subjects to perform active versus passive information processing did not affect their duration estimates of the enjoyable stimuli because they recalled similar quantities of information in both treatment conditions.

On the other hand, neutral stimuli are more tiresome and it is plausible to expect a spontaneous trend to pay less attention to them, unless specifically instructed to do otherwise. Indeed, the t-test for the self-reported level of attention devoted to the neutral videos showed a marginal significant difference between active versus passive treatment conditions $Mean_{Neutral, Active} = 4.98, SD = 1.46; Mean_{Neutral, Passive} = 4.25, SD = 1.49; t = 1.807; \rho = .07$). Thus, the significantly higher duration estimate for the neutral videos in active versus passive processing conditions in Figure 7 may be explained by more information having been remembered, which increased perceived duration.

ii) Dependent variable: sum of the estimates for each video (SSE)

In Study 1, subjects were also asked to estimate the duration of each video in the stimulus series. They provided their estimates in minutes and seconds, which were later converted into their equivalent measure in seconds when creating the database (eg., 1 minute and 15 seconds = 75 seconds). After this, the dependent variable was calculated by adding up the duration estimate of the four videos, and it was saved as a new variable in the database, called SSE (Sum of Segments' Estimates). Thus:

$$SSE = \sum_{i=1}^4 (\text{Duration Estimate Video}_i)$$

The hypotheses involving SSE as dependent variable in Chapter 2 were:

H4: *The sum of segments' estimates will not be equal to the single estimate for the entire sequence of stimuli.*

H5: *The sum of segments' estimates will be more accurate than a single duration estimate for the entire sequence of stimuli.*

H6: *The sum of segments' estimates will show lower variability compared to a single duration estimate for the entire sequence of stimuli.*

H7: *The effect of a time delay will be greater on the single duration estimate for the entire sequence of stimuli than on the sum of segments' estimates.*

To test for H4, a paired t-test for the mean difference between both dependent variables was conducted. As hypothesized, the sum of segments' estimates (SSE) was significantly different ($Mean_{SSE} = 455.742$, $SD_{SSE} = 166.801$; $Mean_{DES} = 495.750$, $SD_{DES} = 215.584$; $t(-2.983)$; $p < .001$) from the duration estimate for the entire sequence (DES). Thus, H4 is supported. This finding shows that “the whole is greater than the sum of its parts”, because the duration estimate elicited for the entire series of videos (DES) is significantly greater than the sum of the segment's estimates (SSE). The t-test also showed that the mean value obtained for both dependent variables overestimates the clock duration of the entire series of four videos (383 seconds), but the mean value obtained for SSE is more accurate relative to DES (the mean value is closer to actual duration of the stimulus series). Thus, H5 is supported.

To test for H6, given that each subject provided an estimate for SSE and for DES, an F-test for difference in variances was conducted (Hair et al., 2006). The test showed that the variability of the duration estimate for the entire series (DES) was significantly greater ($Var_{DES} = 46476.35; Var_{SSE} = 27822.8; F(209, 209) = 1.536; \rho < .001$) than the variability of the sum of the segments' estimates (SSE). Thus, H6 is supported.

To examine H7, a t-test was conducted. Results showed that the sum of the segments' estimates (SSE) did not differ in the immediate treatment condition ($Mean_{Immediate}^{SSE} = 455.07, SD = 174.48; Mean_{Delayed}^{SSE} = 456.54, SD = 157.92; t = -.063, \rho = .950$) relative to the delayed treatment condition. On the other hand, the ANOVA test presented in Tables 8.a and 8.b for the single estimate for the duration of the entire series (DES) was significantly different in the immediate treatment condition relative to the delayed one ($Mean_{Immediate}^{DES} = 481.43; Mean_{Delayed}^{DES} = 513.07; (F(1, 202) = 2.945; one - tailed \rho = .044)$). This findings show that the sum of the segments' estimates is not affected by the time delay, as it was the estimate for the entire experience (DES). Thus, H7 is supported. It is important to highlight that the estimate for the entire experience (DES) was longer in the delayed estimates condition compared to immediate estimates condition, which does not provide support for memory decay effects. A plausible explanation is provided in the discussion section.

Although there are no corresponding hypotheses, further t-tests were conducted in order to examine whether other manipulations affected the difference between the whole and the parts. Time perception of the entire sequence (DES) did not significantly

differ from the sum of the segments' estimates (SSE) in the enjoyable stimulus condition ($Mean_{Enjoyable}^{DES} = 480.09, SD = 173.72; Mean_{Enjoyable}^{SSE} = 463.92, SD = 142.71; t = .849, \rho = .400$), but it was significantly different in the neutral stimulus condition ($Mean_{Neutral}^{DES} = 506.76, SD = 231.55; Mean_{Neutral}^{SSE} = 436.38, SD = 177.47; t = 3.241, \rho = .002$). In other words, “the whole is greater than the parts” when subjects are exposed to neutral stimulus but not when exposed to an enjoyable one.

Time perception of the entire sequence (DES) did not significantly differ from the sum of the segments' estimates (SSE) in the passive processing stimulus condition ($Mean_{Passive Processing}^{DES} = 473.87, SD = 202.25; Mean_{Passive Processing}^{SSE} = 445.56, SD = 165.88; t = 1.557, \rho = .122$), but it was significantly different in the active processing condition ($Mean_{Active Processing}^{DES} = 519.36, SD = 227.76; Mean_{Active Processing}^{SSE} = 466.72, SD = 167.91; t = 2.653, \rho = .009$). In other words, “the whole is greater than the parts” for time perceptions when subjects engage in active stimulus processing but not when they perform passive stimulus processing.

Time perception of the entire sequence (DES) did not significantly differ from the sum of the segments' estimates (SSE) in the immediate estimates condition ($Mean_{Immediate}^{DES} = 481.43, SD = 215.72; Mean_{Immediate}^{SSE} = 455.07, SD = 174.48; t = 1.517, \rho = .132$), but it was significantly different in the delayed estimates condition ($Mean_{Delayed}^{DES} = 513.07, SD = 225.27; Mean_{Delayed}^{SSE} = 456.54, SD = 157.92; t = 2.709, \rho = .008$). In other words, “the whole is greater than the parts” in time perceptions when subjects estimate durations in the delayed condition but not when produce their estimates immediately after stimuli exposure.

iii) Dependent variable: error of the duration estimate for each video

In this study, accuracy is taken as the ratio produced by dividing the interval's duration-estimate by the interval's actual clock duration. For example, if a subject produces a perfectly accurate estimate, the estimate must be equal to the clock duration and perfect accuracy is equal to one. The error in this case is zero.

On the other hand, accuracy is greater than one if the subject overestimates the interval's duration, and lower than one if the interval is underestimated. Thus, the error of the estimate (E) is measured in this study as the absolute deviation of the duration estimate from perfect accuracy, and is calculated as in the equation below (Brown and Boltz, 2002):

$$E = \left| \frac{\text{Interval's Duration Estimate}}{\text{Interval's Clock Duration}} - 1 \right|$$

Each of the four videos was calculated separately. As the videos in the stimulus series have different lengths, their error was calculated as in the equations below.

$$EV1 = \left| \frac{\text{Duration Estimate Video 1}}{61} - 1 \right|$$

$$EV2 = \left| \frac{\text{Duration Estimate Video 2}}{32} - 1 \right|$$

$$EV3 = \left| \frac{\text{Duration Estimate Video 3}}{194} - 1 \right|$$

$$EV4 = \left| \frac{\text{Duration Estimate Video 4}}{96} - 1 \right|$$

Where:

EV1 = Error of the duration estimate for video 1

EV2 = Error of the duration estimate for video 2

EV3 = Error of the duration estimate for video 3

EV4 = Error of the duration estimate for video 4

In Chapter 2, the hypothesis associated to these dependent variables was:

H8: *The error of the duration estimate for the first and the last segment in the series will be lower than the error of the segments embedded in the series when subjects produce estimates immediately after stimuli exposure, but not when they are produced after a time delay.*

In order to test this hypothesis, it was necessary to compute the sum of the error of videos 1 and 4 (EV1V4) and the sum of the error of videos 2 and 3 (EV2V3) as a new variables in the database. Thus, according to H8, it is postulated that EV1V4 will be significantly lower than EV2V3 when subjects produce their estimates immediately after stimuli exposure, but not after a time delay. The sum of the estimates error for videos 1 and 4 was significantly lower than the error of videos 2 and 3 in the immediate estimates condition ($Mean_{Immediate}^{EV1V4} = 1.089; SD = .767; Mean_{Immediate}^{EV2V3} = 1.308; SD = 1.102; t = -2.385; \rho = .019$), but not in the delayed estimates condition ($Mean_{Delayed}^{EV1V4} = 1.045; SD = .757; Mean_{Delayed}^{EV2V3} = 1.214; SD = 1.254; t = -1.860; \rho = .066$). Thus, the t-tests supported H8.

This is an interesting result because it provides evidence to introduce theory on primacy/recency effects into time perception research. The findings suggest that in time perception, memory failures affect individuals' capability to better recall the duration of the first and the last stimuli in the series, so that their time estimates are more accurate

relative to the intervals embedded in the series only when they are produced immediately after stimuli exposure but not when produced after a time delay. Thus, primacy/recency effects in time perception seem to be moderated by memory performance.

Even though it was not hypothesized, further t-tests were conducted in order to examine whether the error of the duration estimates is driven by type of information processing or stimulus enjoyment. Thus, the sum of the estimates error for videos 1 and 4 was significantly lower than the error of videos 2 and 3 for the neutral stimuli series ($Mean_{Neutral}^{EV1V4} = .913; SD = .668; Mean_{Neutral}^{EV2V3} = 1.317; SD = 1.311; t = -3.681; \rho < .001$), but not for the enjoyable ones ($Mean_{Enjoyable}^{EV1V4} = 1.197; SD = .812; Mean_{Enjoyable}^{EV2V3} = 2.04; SD = 1.067; t = -.094; \rho = .926$). This is an interesting finding because findings in section i) indicated that stimulus enjoyment did not affect the duration estimate produced for the entire sequence (DES), but here it affects time perception of some of its parts.

On the other hand, the sum of the estimates error for videos 1 and 4 was significantly lower than the error of videos 2 and 3 in the passive processing condition ($Mean_{Passive}^{EV1V4} = 1.098; SD = .778; Mean_{Passive}^{EV2V3} = 1.323; SD = 1.154; t = -2.674; \rho = .009$), but not in the active processing condition ($Mean_{Active}^{EV1V4} = 1.029; SD = .742; Mean_{Active}^{EV2V3} = 1.184; SD = 1.221; t = -1.561; \rho = .122$). These findings illustrate that when performing passive processing, individuals were able to better recall and estimate the duration of the first and last video compared to those embedded in the series. However, performing active information processing helped subjects to recall all segments in the series, so that accuracy of their estimates did not significantly differ.

iv) Confidence measures: confidence bounds and self-assessed confidence

In Study 1, subjects were asked to estimate the briefest and longest duration-range that should encompass their best estimate for each of the four videos. They were told to “*estimate the duration of each video in minutes and seconds*” and to put a range about that estimate: “*what is the shortest time the video could have lasted and what is the longest time?*” They also had to express their level of confidence that the range estimate would actually contain their best estimate by using a seven-point Likert scale. The former is an objective measure of confidence (confidence bounds) and the latter (self-assessed confidence) is subjective (Spence and Brucks, 1997).

Confidence bounds

Subjects were asked to produce a duration range around their best estimate for each video in the stimulus series: the shortest and longest possible duration of each video that would contain their best estimate, which is an objective measure of confidence. Given that the videos in the series have different lengths, it was necessary to compute a Duration Range Ratio (DR). This variable was calculated by dividing the absolute difference between the longest and the shortest possible duration of each video (in seconds) by its best estimate (in seconds). Thus:

$$DRV_i = \left| \frac{\text{Longest Duration } V_i - \text{Shortest Duration } V_i}{\text{Best Estimate } V_i} \right|$$

$$V_i = \text{Video } i$$

$$i = 1, 2, 3, 4$$

Where:

Longest Duration_{video_i} = Estimate for longest possible duration for video *i*

Shortest Duration_{video_i} = Estimate for shortest possible duration for video *i*

Best Estimate_{video_i} = Best Estimate for how long video *i* took

i = 1, 2, 3, 4.

Then, the duration-range ratios of videos 1 and 4 were added up and labelled DRV1V4 in the database. The duration-range ratios of videos 2 and 3 were added up and labelled DRV2V3.

Results showed that the sum of the duration-range for videos 1 and 4 was significantly lower than the duration-range of videos 2 and 3 in the immediate estimates condition ($Mean_{Immediate}^{DRV1V4} = 94.408; SD = 46.03; Mean_{Immediate}^{DRV2V3} = 108.860; SD = 95.458; t = -2.089; \rho = .039$), and in the delayed estimates condition ($Mean_{Delayed}^{DRV1V4} = 103.242; SD = 53.799; Mean_{Delayed}^{DRV2V3} = 114.568; SD = 64.68; t = -2.403; \rho = .018$).

Further t-tests were conducted in order to examine whether the duration range of the estimates around videos 1 and 4 versus videos 2 and 3 was affected by type of information processing or stimulus enjoyment. The duration-range for videos 1 and 4 was significantly lower than the duration-range of videos 2 and 3 in the active processing condition ($Mean_{Active}^{DRV1V4} = 100.168; SD = 53.32; Mean_{Active}^{DRV2V3} = 121.118; SD = 104.54; t = -2.620; \rho = .010$), but not in the passive processing condition ($Mean_{Passive}^{DRV1V4} = 96.770; SD = 46.42; Mean_{Passive}^{DRV2V3} = 102.477; SD = 54.65; t = -1.509; \rho = .134$). On the other hand, individuals exposed to the neutral stimuli series provided a significantly lower duration-range for videos 1 and 4 ($Mean_{Neutral}^{DRV1V4} = 99.163; SD = 55.79; Mean_{Neutral}^{DRV2V3} = 121.142; SD = 108.76; t =$

-2.618 ; $\rho = .010$), but those who were exposed to the enjoyable stimuli did not ($Mean_{Enjoyable}^{DRV1V4} = 97.741$; $SD = 44.07$; $Mean_{Enjoyable}^{DR2V3} = 102.955$; $SD = 49.22$; $t = -1.545$; $\rho = .125$).

Overall, results show a tendency to provide a lower range (hence, to be more confident) around the first and last video compared to those that were embedded in the series. Subjects were more confident about their estimates for videos 1 and 4 in the immediate estimates condition, delayed estimates condition, when exposed to neutral stimuli and when performing active information processing. Interestingly, results from section iii) showed that their duration estimates were more accurate for the first and last videos in the immediate-estimates treatment condition and when exposed to neutral stimuli series, but not when exposed in the delayed estimates condition nor in the active processing condition. This means that subjects were overconfident in the delayed estimates and active processing conditions, because their higher confidence level was not justified by higher estimates' accuracy for videos 1 and 4. However, they were right in the immediate estimates and neutral stimuli conditions (their duration estimates for the first and last video were more accurate and they were more confident about them).

On the other hand, participants' confidence level did not differ for the first and last video compared to those embedded in the series when exposed to the enjoyable stimuli series; which is consistent with a not significant difference between these estimates' accuracy. Finally, confidence levels of videos 1 and 4 did not differ from the confidence levels of videos 2 and 3 when conducting passive processing, but they were actually more accurate. In other words, subjects were underconfident. Figure 8 summarizes results for the intersection between accuracy and confidence levels.

Figure 8.
Accuracy and objective confidence for videos 1 and 4 compared to videos 2 and 3

		ACCURACY	
		HIGHER	NOT HIGHER
OBJECTIVE CONFIDENCE	HIGHER	CONSISTENT JUDGEMENTS * In the immediate-estimates condition. * In the neutral-stimuli condition.	OVERCONFIDENT JUDGEMENTS * In the delayed-estimates condition. * In active-processing conditions.
	NOT HIGHER	UNDERCONFIDENT JUDGEMENTS * In passive processing conditions.	CONSISTENT JUDGEMENTS * In enjoyable-stimuli condition.

In sum, it is possible to classify how confident subjects were about the accuracy of their measures in four scenarios. Results show that subjects were more accurate and more confident in their estimates for the first and the last video relative to those embedded in the series when they produced their estimates immediately after stimulus exposure and when exposed to the neutral stimuli series. Participants correctly expected to be more accurate on videos 1 and 4 and they actually were (consistent judgement).

A second scenario shows that participants' accuracy was not significantly higher and they did not express a higher level of confidence on their estimates for videos 1 and 4 compared to videos 2 and 3 when exposed to the enjoyable videos. They did not expect to be more accurate and they were actually not (consistent judgement).

Subjects were overconfident regarding the accuracy of their estimates in the active processing condition and when estimates were elicited after a time delay. They expected to be more accurate when estimating the duration of the first and last video relative to those embedded in the series, but they were actually not.

Finally, participants were underconfident about the accuracy of their estimates in the passive processing condition. They did not expect to be more accurate on their estimates for the first and last video relative to those embedded in the series, but they actually were.

Self-assessed confidence

The subjective measure of confidence for the best estimate for each video consisted of a self-reported level of confidence. Subjects were provided with a seven-point scale and were asked to express their level of confidence that the duration range around their best estimate actually contained the true clock duration of the video (1= Not at all confident, 7= Absolutely confident). To test for self-reported confidence, the mean of the confidence level for videos 1 and 4 was computed and labelled CONV1V4 in the database. The mean of the confidence level for videos 2 and 3 was computed and labelled CONV2V3.

Overall, results show that individuals did not feel more confident about their duration estimates for videos 1 and 4 relative to those embedded in the series ($Mean_{CONV1V4} = 4.454; SD = 1.20; Mean_{CONV2V3} = 4.316; SD = 1.25; t = 1.759; \rho = .08$). Subjects only felt more confident about their estimates for videos 1 and 4 when they were exposed to the neutral stimuli ($Mean_{Neutral}^{CONV1V4} = 4.489; SD =$

1.17; $Mean_{Neutral}^{CONV2V3} = 4.045$; $SD = 1.31$; $t = 3.385$; $\rho = .001$), but not when exposed to the enjoyable ones ($Mean_{Enjoyable}^{CONV1V4} = 4.424$; $SD = 1.23$; $Mean_{Enjoyable}^{CONV2V3} = 4.553$; $SD = 1.14$; $t = -1.523$; $\rho = .131$). Moreover, participants did not differ in self-assessed confidence across immediate versus delayed-estimates treatment conditions ($Mean_{Immediate}^{CONV1V4} = 4.569$; $SD = 1.14$; $Mean_{Immediate}^{CONV2V3} = 4.413$; $SD = 1.23$; $t = 1.599$; $\rho = .113$); ($Mean_{Delayed}^{CONV1V4} = 4.315$; $SD = 1.26$; $Mean_{Delayed}^{CONV2V3} = 4.20$; $SD = 1.27$; $t = .910$; $\rho = .365$) neither across active versus passive processing conditions ($Mean_{Active}^{CONV1V4} = 4.549$; $SD = 1.19$; $Mean_{Active}^{CONV2V3} = 4.430$; $SD = 1.22$; $t = 1.079$; $\rho = .283$); ($Mean_{Passive}^{CONV1V4} = 4.367$; $SD = 1.21$; $Mean_{Passive}^{CONV2V3} = 4.211$; $SD = 1.26$; $t = 1.392$; $\rho = .167$).

In sum, subjects only felt more confident about their estimates for videos 1 and 4 relative to those videos embedded in the series when they were exposed to the neutral stimuli. This judgement is consistent with the higher level of accuracy and the higher objective confidence obtained for the neutral stimulus condition.

4.4 Summary of findings and discussion

The aim of Study 1 was twofold. First, it aims to determine whether type of stimulus and cognitive processes such as attention and memory affect time perception of a series of events past, when subjects retrieve time-filling information from long-term memory. Second, Study 1 focuses in exploring how time perceptions are affected when individuals are cued to reconstruct the different segments of an experience as opposed to cueing them to recall the experience as a whole. Study 1 also introduces audio-visual

stimuli in the experiment design which compared to the traditional visual or auditory stimuli found in the literature, better represents the type of real-life situations that individuals experience during a normal day.

Time perception and cognitive processes

Study 1 investigated the effect of information processing on retrospective time perception. It was expected that subjects who performed active information processing would devote less attentional resources to tracking the passage of time and would consequently be less accurate compared to subjects in passive processing conditions.

Findings revealed that information processing distorts perception of time, and the duration estimate for the entire series of stimuli was longer and less accurate when performing active relative to passive information processing. This effect was enhanced when subjects were exposed to neutral stimuli, but not when they were exposed to the enjoyable stimuli series. The self-reported level of attention devoted to processing the enjoyable videos in active versus passive processing conditions showed no significant difference, which suggests that the enjoyable videos were engaging even when participants were cued to perform passive processing. Thus, subjects may have recalled and used similar amounts of filling information as a cue to duration estimates (Bailey and Areni, 2006; Kellaris et al., 1996), so that their time estimates for enjoyable videos did not differ across the active/passive treatment conditions.

Following the same rationale, neutral videos may have been less engaging, so subjects devoted more attentional resources to process them only if encouraged to. Indeed, self-reported level of attention devoted to the neutral videos was higher in the

active versus the passive treatment condition. Thus, it can be suggested that more information was remembered when performing active processing, which increased perceived duration for neutral stimuli.

Another expectation of Study 1 was that duration estimates elicited after a time delay would be less accurate than duration estimates elicited immediately after stimulus exposure. Findings provided support for this. In Study 1 the duration estimate produced after the time delay was significantly longer and less accurate than the estimates elicited immediately after stimulus exposure, a finding that is consistent with Pedri and Hesketh, 1993. However, Study 1 showed no evidence for memory decay in time perceptions of serial events. Time delays are expected to create knowledge gaps that shorten perceptions of time. A possible explanation for this result may be the short time delay (90 seconds) that was allocated to performing the filler task in Study 1. It is plausible to advance that the filler task was not hard or long enough to cause participants to store stimuli information in long-term memory in order to devote their cognitive resources to processing the filler task. In other words, participants may have kept stimuli information in working memory when performing the filler task for 90 seconds, and use it in conjunction with information processed when performing the filler task to produce their duration estimates for the entire experience. A second possible explanation is that subjects may have made up interval filling information. In both scenarios, more information may have been associated to the stimuli in the delayed condition, which may explain the lengthened duration estimates. This issue needs to be addressed in Study 2 in order to explore whether longer time delays would shorten duration estimates or cause subjects to underestimate time.

Time perception when having fun

In Study 1 it was also expected that time perceptions for a series of stimulus would be affected by stimulus enjoyment. Duration estimates for enjoyable times were expected to be less accurate than estimates for neutral ones. Findings show that the enjoyable stimuli did not affect the duration estimate produced for the entire stimuli sequence (DES) neither for the sum of the segments' estimates (SSE) compared to the estimates produced for the neutral stimuli series. However, results indicated that stimulus enjoyment affected the estimates accuracy of some of its parts. This issue needs to be addressed in Study 2.

Time perception and event reconstruction

Findings illustrate that time perception for events past are significantly longer and less accurate if subjects are cued to reconstruct and estimate the experience as a whole, as opposed to retrieving and estimating its different subparts. Thus, Study 1 illustrates that in time perception “the whole is greater than the sum of its parts”, and this effect is enhanced (bigger gap) when duration estimates are produced after a time delay, when subjects are exposed to neutral events, and when subjects perform active stimulus information processing. Moreover, the variability of the single duration estimate for the entire series was significantly greater than the variability of the sum of the segments' estimates. These are interesting findings because they provide support to apply literature in perceptions of events and memory psychophysics regarding reconstruction of physical objects and events (Hubbard, 1994; Kerst, 1978; Newton et al., 1977; Petrusic and Baranski, 1998; Zacks and Tverzki, 2001), into time perception research.

Time perception and primacy/recency effect

Study 1 illustrates that subjects' estimates for the first and last video in the stimuli series relative to those embedded in the series were more accurate when produced immediately after stimuli exposure, but not after a time delay. This is an interesting result because it provides evidence to introduce theory on primacy/recency effects into time perception research.

Moreover, the accuracy of the duration estimates of videos 1 and 4 was significantly higher than the accuracy of videos 2 and 3 when performing passive information processing. These findings illustrate that when performing passive processing, individuals were able to better recall and estimate the duration of the first and last video compared to those embedded in the series. However, performing active information processing helped subjects to recall all segments in the series, so that accuracy of their estimates did not significantly differ. Finally, the accuracy of the duration estimates of videos 1 and 4 was significantly higher than the accuracy of videos 2 and 3 when subjects were presented with the neutral stimuli series, but not when processing the enjoyable one.

Accuracy and confidence in time perception

Results from Study 1 also show that subjects were more accurate and more confident in their estimates for the first and the last video relative to those embedded in the series when they produced their estimates immediately after stimulus exposure and when exposed to the neutral stimuli series. Participants produced veridical judgements

because they were more confident about the accuracy of videos 1 and 4 and they actually were.

Similarly, participants produced veridical judgements regarding the accuracy of their estimates when exposed to the enjoyable videos. They were not more confident about their duration estimates for videos 1 and 2 relative to videos 2 and 3 and they were actually not.

However, subjects were overconfident regarding the accuracy of their estimates in the active processing condition and when estimates were elicited after a time delay. They were more confident when estimating the duration of the first and last video relative to those embedded in the series, but they were actually not more accurate.

Finally, participants were underconfident about the accuracy of their estimates in the passive processing condition. They were not more confident about the accuracy of their estimates for the first and last video relative to those embedded in the series, but they actually were more accurate for videos 1 and 4.

Need for further research

Findings from Study 1 also revealed the need for further research. A first interesting research gap is a better understanding of the effect of memory decay on time perception. Contrary to what memory decay effects would postulate in this case, some estimates actually increased after a time delay took place (eg., the estimates for the neutral videos increased in the delayed estimates condition). As advanced earlier in this section, a possible explanation could be that the time delay was rather short, only one

and a half minutes. Thus, a second study could also explore whether longer time delays would shorten duration estimates or provoke subjects to underestimate time.

A second research issue is related to the role of stimulus enjoyment in time perceptions. The enjoyable stimuli did not affect the duration estimate produced for the entire stimuli sequence (DES) neither for the sum of the segments' estimates (SSE) compared to the estimates produced for the neutral stimuli series. However, results indicated that stimulus enjoyment affected the estimates accuracy of some of its parts. Study 2 aims for a better understanding of time perceptions when having fun.

The last research issue is related to when the time estimates are elicited. In Study 1, subjects were asked to retrieve and estimate the duration of the four segments first, and after a few filler questions in the next page, they were asked to estimate how long the four videos taken together took. This could have introduced a bias in the measures because subjects would keep in mind their first series of time estimates and consequently provided lengthened duration for the entire experience. If that is true, “the whole may not be greater than the parts”. In order to examine if subjects were or not cued by when the measures were produced, the order of the measures was counter-balanced in Study 2.

Thus, the next chapter further explores the question “Does time fly when having fun?” by testing whether memory decay shortens time perception for a series of enjoyable events. The experiment design uses longer time delays after stimulus exposure before eliciting duration estimates. It also controls for cueing effects when reconstructing the experience by counterbalancing when the duration estimates are elicited.

CHAPTER 5

STUDY 2: METHODOLOGY AND FINDINGS

5.1 Introduction

The objectives of Study 2 are threefold. First, it aims to better understand the effect of memory performance on time perception. As some estimates in Study 1 increased after a time delay took place, Study 2 explores whether longer time delays shorten duration estimates or provoke subjects to underestimate time. Second, it further explores the role of stimulus enjoyment. In Study 1, stimulus enjoyment did not affect the duration estimate for the entire stimuli sequence or for the sum of the segments' estimates. However, stimulus enjoyment affected the accuracy of some segments' estimates. Third, Study 2 examines whether time perception is affected by the order in which subjects produce their duration estimates. For instance, subjects in Study 1 may have kept in mind their first series of estimates and consequently provided lengthened duration for the entire experience. Thus, the order of the measures was counter-balanced in Study 2.

Thus, Study 2 further explores the question “Does time fly when having fun?” by testing whether time delays shorten time perception for a series of enjoyable events. The experiment design uses longer time delays after stimulus exposure. It also controls for cueing effects when reconstructing the experience by counterbalancing when the duration estimates are elicited.

This chapter is organized as follows. Section 5.2 of this chapter presents the experiment design, procedure and measures included in Study 2. In section 5.3, data analysis and findings are presented. Finally, section 5.4 discusses general conclusions.

5.2 Methodology chosen for Study 2

Study 2 consisted of a 2x3 between subjects design (*Duration estimate for the entire series (DES) elicited before Sum of the segments' estimates (SSE)/ DES elicited after SSE by immediate/ short delay/ long delay time estimates*). Table 10 outlines the six treatment conditions created by the 2x3 design.

Table 10.
Experimental conditions in Study 2

Manipulation of Memory	Manipulation of Measures Elicitation	Treatment Conditions
No Delay Estimates (Immediate)	DES before SSE	Immediate Estimates x DES before SSE
	DES after SSE	Immediate Estimates x DES after SSE
Short Delay Estimates (5 minutes)	DES before SSE	Short Delay Estimates x DES before SSE
	DES after SSE	Short Delay Estimates x DES after SSE
Long Delay Estimates (90 minutes)	DES before SSE	Long Delay Estimates x DES before SSE
	DES after SSE	Long Delay Estimates x DES after SSE

Each subject was exposed to the enjoyable series of audiovisual stimuli that was used in Study 1. Participants were told that after watching the videos they would be asked questions about the content of the videos, but they were not aware of the timing task.

Manipulations

For the manipulation of time delay, subjects differed in when they were asked to provide time estimates. Immediate duration-estimates were asked for right after subjects were exposed to all four videos. Short delayed estimates were provided after subjects completed two non-related filler tasks for five minutes. The filler tasks consisted of a

word stem completion exercise (i.e., name a city that begins with A____, B ____, etc.), after which they were asked questions related to food preferences and credit cards usage. Long delay estimates were provided an hour and a half after stimulus exposure. For this last treatment condition, subjects were presented with the videos at the beginning of a marketing lecture/tutorial, and asked to complete the questionnaire at the end of the class.

For the manipulation of measures, both the duration estimate for the entire sequence of videos (DES) and the duration estimate of each video were counterbalanced in the questionnaire. Subjects in the “DES before SSE” treatment condition were asked to retrieve and estimate the duration of the entire stimuli series first and then to provide duration estimates for each video. Participants in the “DES after SSE” condition were first cued to estimate the duration of each video and their confident bounds first, and to estimate the duration of the entire experience later. (See appendix 3 for a sample of the questionnaire used in Study 2).

Stimulus material

The audiovisual stimulus for duration judgement was the enjoyable series of audiovisual stimuli that was used in Study 1. The collection of four enjoyable videos was presented to participants in the same order as in Study 1. Table 11 shows the arrangement of the series of videos and their clock durations. The content of the videos was described in Chapter 3.

Table 11.
Arrangement of audio-visual stimuli in Study 2

Enjoyable Videos	Clock Duration (in seconds)
Hidden Camera (TV show)	61
Monkeys in suits (TV ad)	32
Comedians (TV show)	194
Toyota (TV ad)	96
Total Clock Duration	383

Procedure

During the recruitment stage, subjects were randomly assigned to one of the six experimental conditions presented in Table 10. Upon arrival to a lecture auditorium equipped with chairs, computer, projector and speakers, participants were given a questionnaire and told to seat and wait for instructions.

An “Explanatory Statement” and the “General Instructions” on the front page of the questionnaire were read aloud by the researcher to all participants in the room. On the second page of the questionnaire the instructions informed them that they would be shown a series of four videos on the screen, all of them related to daily-life episodes that any of them could experience during a normal day. Subjects were not made aware of the time estimation task. During exposure to the audiovisual stimuli, the four enjoyable videos were played consecutively on the screen, like many of us would switch channels at home using a remote control.

Immediately after watching the stimuli, subjects were asked to answer the questions. For participants in the no-delay condition (immediate estimates), the first three questions were related to the content of the videos, followed by the questions

related to the duration estimate tasks. Participants in the short delay condition had to answer the same three questions related to the content of the videos, plus the filler task, which lasted for five minutes. They then provided their duration estimates. Subjects in the long delay condition were distributed the questionnaire at the end of their marketing lecture/tutorial, and had to answer the three questions related to the content of the videos first, followed by the questions related to the duration estimate tasks.

After producing these estimates, they had to express their level of confidence that their estimate range would actually contain the clock duration of each video. Finally, they answered questions related to the manipulation checks. After completion of the questionnaire, students were thanked for participating and dismissed.

Measures

Study 2 used the same measures applied in Study 1. Thus, subjects were asked to estimate the duration of each video (best estimate), and the briefest and longest duration-range that should encompass their best estimate. They also had to express their level of confidence that the range estimate would actually contain the true duration of the video by using a seven-point Likert scale. After answering questions related to the content of the videos they were asked to estimate the total time-duration of the four videos taken together. All these measures were described in detail in Chapter 4.

Subjects

A total of 320 university students aged from 18-30 years old volunteered for the study for course credit. Because the students received extra credit-points for participating, they were asked to provide their names on a separate page, hence anonymity was guaranteed. Participants were allowed to discontinue the study at any time, if desired. The final sample size was 300 subjects, who completed the questionnaire.

5.3 Data analysis and findings

Manipulation checks were analysed first to check for memory performance in the delayed estimates conditions (short/long delay), as opposed to the no-delay condition. After this, data analysis was conducted and a discussion of the main findings was also outlined.

Manipulation checks

The last section of the questionnaire was dedicated to the manipulation checks. To check for how enjoyable the stimulus was, the subjects were asked: “Overall, how entertaining were the four videos?” and then asked to use a seven-point scale to rate how enjoyable the videos were (1= Not at all enjoyable; 7= Very much enjoyable). To check for memory performance, participants were asked to express level of agreement or disagreement with the statement “I can remember lots of details in the videos”,

respectively. They were asked to mark down their preference on a seven-point scale (1= Strongly disagree, 7= Strongly agree).

A manipulation check was carried out on the series of stimuli to test for memory performance. When providing duration estimates, individuals in the no-delay condition produced their estimates immediately after being exposed to the videos, while individuals in the two delayed conditions produced their estimates after completing a series of filler tasks for five minutes (short delay) and after their marketing class was finished (long delay). This filler tasks are expected to provoke individuals to store stimuli information in long term memory, so that they experience memory decay when recalling information related to the videos. In the questionnaire, this was measured by a self-reported evaluation of memory for stimulus content, using the statement “I can remember lots of details from the videos” followed by a seven-point scale (1= Strongly Disagree; 7= Strongly Agree).

The t-test showed that the self-reported measure of how much was remembered did not decay after subjects completed the filler task. Individuals perceived they could recall similar amount of information in the no delay and short delay condition ($Mean_{No\ Delay} = 4.38; SD = 1.334; Mean_{Short\ Delay} = 4.58; SD = 1.363; t = -1.122; \rho = .263$. Levene’s test ($F(1, 248) = .202; \rho = .654$); in the no delay relative to long delay condition, ($Mean_{No\ Delay} = 4.38; SD = 1.334; Mean_{Long\ Delay} = 4.50; SD = 1.454; t = -.504; \rho = .263$. Levene’s test ($F(1, 140) = .710; \rho = .401$) and in the short delay relative to the long delay condition ($Mean_{Short\ Delay} = 4.58; SD = 1.363; Mean_{Long\ Delay} = 4.50; SD = 1.454; t = .399; \rho = .690$. Levene’s test ($F(1, 222) = .327; \rho = .568$).

Thus, the self-reported measure for how much was remembered of the content of the videos did not show memory decay concerns among participants. They think they remember well across all conditions. In the following sections findings show that they could not properly remember and estimate the duration of the stimuli series after time delays took place.

Memory and duration estimate for the entire series (DES)

Study 2 further explores the role of memory decay and cueing effects on time perception of a series of enjoyable stimuli. The duration estimate for the entire series (DES) was measured by asking the subjects: “Taken together, how long do you think the four videos lasted?” Subjects provided estimates in minutes and seconds, which were transferred into its equivalent amount in seconds in the database.

First, ANOVA assumptions were tested. Levene’s test showed that the homogeneity of variance assumption was not violated ($F(5, 294) = 2.005; p = .078$). The Kolmogorov-Smirnov test showed that normality of the dependent variable cannot be assumed ($KS(300) = .110; p < .001$). Outliers in the dataset were identified using the same technique applied in Chapter 4. All 13 data points representing outliers were replaced by their predicted value. After this transformation was conducted, both normality and homogeneity of variance could be assumed: the Kolmogorov-Smirnov test for normality of the dependent variable was $KS(300) = .095; p = .027$ and the Levene’s test of equality of error variances was $F(5, 294) = 2.177; p = .057$.

The purpose of Study 2 is to explore the memory decay effect on time perception of a series of enjoyable stimulus and to determine whether time estimates were affected by the order in which the measures were provided by participants. The ANOVA tests conducted in order to examine the main effects for the two main manipulations outlined in Study 2. Tables 12.a and 12.b present the ANOVA tests and relevant descriptive statistics, respectively.

Table 12a.
ANOVA tests (2x3 between subjects factorial design)
Dependent variable: duration estimate for the entire series (DES)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Time Condition	703478.542	2	351739.271	14.293	.001
Estimate Condition	257676.046	1	257676.046	10.471	.001
Time condition x Estimate condition	694168.759	2	347084.379	14.635	.003
Error	7234957.428	294	24608.699		

The output in Table 12.a shows a significant main effect for time condition ($Mean_{No\ Delay} = 445.88$; $Mean_{Short\ Delay} = 384.32$; $Mean_{Long\ Delay} = 302.38$, $F(2, 294) = 14.293$; $p = .001$) in the expected direction. Interestingly, subjects overestimated the duration of the entire experience in the no delay condition (clock duration was 383 seconds) and they underestimated the duration of the entire series in the long delay condition.

Because ANOVA tests rejects the null hypothesis if any pair of means is unequal, where the significant difference lies needs to be determined.

This requires post-hoc analysis. Table 13 shows the output for the post-hoc analysis for the time condition (no delay/ short delay/ long delay), using the Tukey's honestly significant distance (HSD) test (Hair et al., 2006).

Table 12b.

Descriptive statistics for ANOVA tests. Dependent variable: DES

Time Condition	Estimate Condition	Mean (in seconds)	Std. Deviation	Sample Size
No Delay	DES taken before	440.74	154.104	34
	DES taken after	449.86	176.484	44
	Total	445.88	166.109	78
Short Delay	DES taken before	367.72	157.759	127
	DES taken after	438.38	177.144	39
	Total	384.32	164.727	166
Long Delay	DES taken before	239.48	118.127	27
	DES taken after	360.93	122.602	29
	Total	302.38	134.158	56
Total	DES taken before	362.51	161.915	188
	DES taken after	422.84	167.260	112
	Total	385.03	166.242	300

Table 13.

One-way ANOVA post-hoc comparisons using Tukey's HSD test

(I) Time Condition	(J) Time Condition	Mean Difference (I-J)	Std. Error	Sig.
No Delay	Short Delay	61.565	21.948	.010
	Long Delay	143.510	28.003	.000
Short Delay	No Delay	-61.565	21.948	.010
	Long Delay	81.944	24.707	.002
Long Delay	No Delay	-143.510	28.003	.000
	Short Delay	-81.944	24.707	.002

Levene's test: $F(2, 297) = 2.723, p = .067$

According to the results of Tukey's test in Table 13, there is a significant mean difference between each paired comparison. Thus, there is evidence to support memory decay effects on time estimates of the entire series of stimulus: the longer the time delay after stimulus exposure, the shorter the duration estimate of the entire series.

In short, the significant effect of the time condition on time perception shows that engaging subjects in filler tasks after stimulus exposure causes them to recall less time filling information when they are asked to produce duration judgements. Clock model literature is consistent with this findings because it assumes that time perception depends on the amount of stimulus information that individuals use to produce their time estimates. Thus, as time delay increased, time estimates for the entire series of events significantly decreased. Findings show that overall, individuals overestimate the clock duration of the entire series when they produce immediate estimates ($Mean_{No\ Delay} = 445.88$ versus $Clock\ Duration = 383$) and they underestimate the true duration of the series after a long delay taking place ($Mean_{Long\ Delay} = 302.38$ versus $Clock\ Duration = 383$).

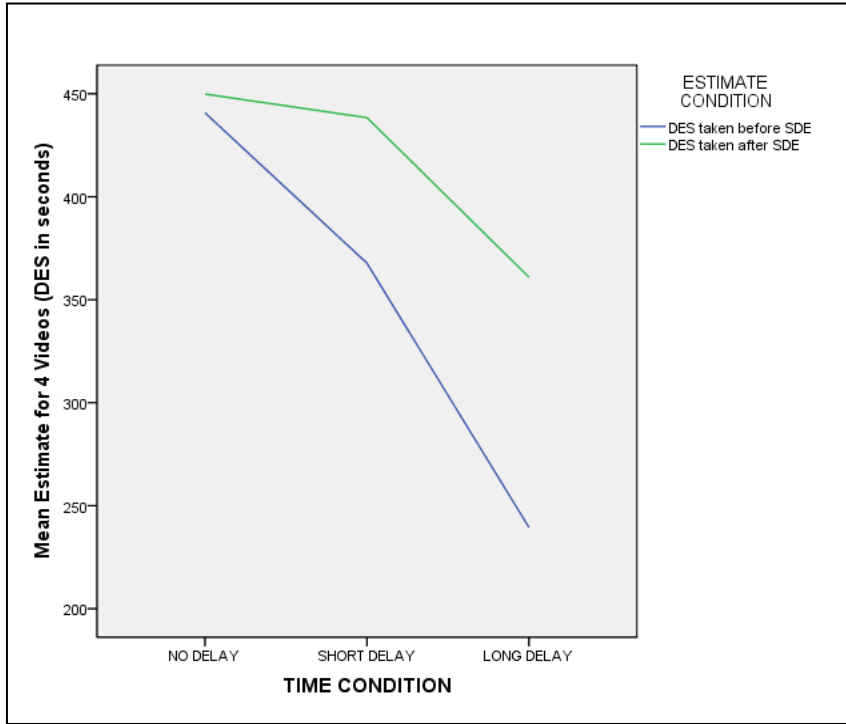
It is important to highlight here that despite self-reported measures claiming subjects could remember equivalent amounts of stimulus information regardless of time delay, elicited duration estimates indicate that they in fact could not recall and reconstruct equivalent amounts of information across treatment conditions. Thus, memory decay shortened perceptions of time: the longer the time delays, the shorter the single duration estimate for the entire experience.

The output in Tables 12.a and 12.b also showed that time perception were affected by when the measures were elicited ($Mean_{DES \text{ taken before SSE}} = 362.51$, $Mean_{DES \text{ taken after SSE}} = 422.84$, $F(1, 294) = 10.471$; $p = .001$). Subjects produced higher estimates for the entire experience after having retrieved the different segments of the stimulus series and estimated their duration. This is an interesting result because it provides support for the presence of cueing effects during experience reconstruction: subjects overestimated the duration of the entire series when they were cued to recall its four segments first.

Finally, the output in Tables 12.a and 12.b also showed a significant interaction effect for time condition by estimate condition ($F(2, 294) = 14.635$; $p = .003$). That is, the influence of memory on the total duration estimate is affected by when the estimates were elicited (DES taken before SSE/DES taken after SSE). This effect is shown in Figure 9.

The effect of memory on time perceptions was enhanced when subjects were asked to recall and estimate the duration of the entire series (DES) before estimating the duration of its different segments (DES taken before SSE), as opposed to those who were asked to produce an estimate for the duration of entire series after having recalled each one of its four segments (DES taken after SSE). In other words, the single duration estimate for the series as a whole (DES) was more sensitive to memory decay when subjects elicited this estimate before recalling its different subparts. Table 14 shows the simple effects analysis for the interaction effect.

Figure 9.
Interaction effect (time condition by estimate condition)



The t-tests for equality of means in Table 14 show that the effect of memory decay on time perception is affected by when the measures are elicited: subjects who were asked to estimate the duration of the entire sequence before recalling its four segments produced significantly lower estimates in the short delay ($Mean_{Short\ Delay, DES\ taken\ before\ SSE} = 367.72$, $Mean_{Short\ Delay, DES\ taken\ after\ SSE} = 438.38$; $t = -2.376$; $p = .019$) and in the long delay ($Mean_{Long\ Delay, DES\ taken\ before\ SSE} = 239.48$, $Mean_{Long\ Delay, DES\ taken\ after\ SSE} = 360.93$, $t = -3.771$, $p < .001$) conditions compared to those who produced their estimate after having recalled and estimated all four segments in the series. However, in the no delay condition, subjects' estimate for the entire experience did not differ. ($Mean_{No\ Delay, DES\ taken\ before\ SSE} = 440.74$, $Mean_{No\ Delay, DES\ taken\ after\ SSE} = 449.86$, $t = -.239$, $p = .812$).

Table 14.**Interaction effect analysis: descriptive statistics and t-tests for equality of means**

Source	Condition	Mean	Sample Size	St. Dev.	t-score	Df.	Sig.	Levene's Test
No Delay	DES taken before SSE	440.74	34	154.104	-.239	76	.812	F(1,76)= .228
	DES taken after SSE	449.86	44	176.484				$\rho = .634$
Short Delay	DES taken before SSE	367.72	127	157.759	-2.376	164	.019	F(1,164) = 1.861
	DES taken after SSE	438.38	39	177.144				$\rho = .174$
Long Delay	DES taken before SSE	239.48	27	118.127	-3.771	54	.000	F(1,54) = .002
	DES taken after SSE	360.93	29	122.602				$\rho = .961$
DES taken before SSE	No Delay	440.74	34	154.104	2.408	159	.017	F(1,159)=.307
	Short Delay	367.72	127	157.759				$\rho = .580$
DES taken before SSE	No Delay	440.74	34	154.104	5.601	59	.000	F(1,59) =4.65
	Long Delay	239.48	27	118.127				$\rho = .035$
DES taken before SSE	Short Delay	367.72	127	157.759	3.988	152	.000	F(1,152) =2.11
	Long Delay	239.48	27	118.127				$\rho = .148$
DES taken After SSE	No Delay	449.86	44	176.484	.295	81	.769	F(1, 81) =.043
	Short Delay	438.38	39	177.144				$\rho = .836$
DES taken After SSE	No Delay	449.86	44	176.484	2.361	71	.021	F(1, 71) =5.02
	Long Delay	360.93	29	122.602				$\rho = .028$
DES taken After SSE	Short Delay	438.38	39	177.144	2.129	66	.037	F(1, 66) =6.32
	Long Delay	360.93	29	122.602				$\rho = .014$

In other words, when individuals produce duration estimates immediately after stimulus exposure, time perception is not affected by how individuals produce their estimates: either by looking at the entire experience as a whole or by examining its different subparts first. It seems plausible to say that because subjects produced their duration estimates immediately after stimulus exposure, they had considerable amounts of stimulus information still in their working memory when estimating time. Hence, the experience seems more filled-in with information, subjects overestimate time and cueing them to look at time as an entire experience or as a series of events first does not alter their time estimates. In addition, these findings are coherent with Study 1. Even if Study 1 had counterbalanced when the measures were taken, results would not have differed in the immediate condition.

T-tests in Table 14 also showed that time perception is more sensitive to the effects of memory decay when subjects are cued to recall and estimate the duration of the entire series of stimulus first (DES taken before SSE). The mean estimate significantly drops from 440.74 seconds in the no delay condition to 367.72 seconds in the short delay condition and to 239.48 seconds in the long delay condition. Thus, participants overestimate the clock duration of the entire series when they produce immediate estimates ($Mean_{No\ Delay} = 440.74$ versus $Clock\ Duration = 383$) and they strongly underestimate the true duration of the series after a long delay ($Mean_{Long\ Delay} = 239.48$ versus $Clock\ Duration = 383$).

However, when subjects were first asked to retrieve and estimate the duration of each video (DES taken after SSE), time perception for the entire experience did not decrease in the short delay condition ($Mean_{No\ Delay, DES\ taken\ after\ SSE} = 449.86$, $Mean_{Short\ Delay, DES\ taken\ after\ SSE} = 438.38$, $t = .295$, $\rho = .769$), and memory

decay only affected time estimates when produced after a long delay ($Mean_{Short\ Delay, DES\ taken\ after\ SSE} = 438.38$, $Mean_{Long\ Delay, DES\ taken\ after\ SSE} = 360.93$, $t = 2.129$, $p = .037$). Thus, data suggests that the experience is more filled-in with information when individuals recall and examine its different segments before actually estimating its entire duration and this estimate is affected by memory decay only after a long delay. This finding is in agreement with Study 1. In Study 1, the duration estimate for the entire experience as a whole was taken after participants recalled its different subparts. The time delay in Study 1 was shorter than in Study 2 (one minute and 30 seconds versus 5 minutes). Tables 8.a and 8.b in Chapter 4 show that the estimate for the entire series of enjoyable videos as a whole did not differ in the immediate relative to the delayed treatment conditions.

Taken together, these results illustrate that memory decay strongly affects time perceptions when individuals are cued to recall the experience as a whole. However, when individuals are cued to recall the different segments of an experience in order to estimate its entire duration, memory decay affects time perception only if estimates are produced after a long delay. These are interesting findings because they provide support to apply theory on event reconstruction into time perceptions research, as it was advanced in Chapter 2. It seems plausible to advance that cueing subjects to recall the entire experience elicits top-down reconstructions, but cueing them to think of the segments of the experience first elicits bottom-up event reconstructions. Individuals who are cued to perform a top-down reconstruction technique tend to recall fewer and more abstract information and consequently to underestimate time. This effect is enhanced by memory decay, when duration estimates are produced after a short and long time delay. On the other hand, individuals who are cued to perform a bottom-up

reconstruction technique tend to recall more concrete information and consequently tend to overestimate time. This effect is moderated by memory decay only when duration estimates are produced after a long delay.

Time perception and “the whole (DES) versus the sum its parts (SSE)”

In Study 2, subjects were also asked to estimate the duration of each video in the stimulus series. As explained in Chapter 4, participants provided their estimates in minutes and seconds, which were later converted into their equivalent measure in seconds when creating the database. After this, the dependent variable was calculated by adding up the duration estimates for the four videos, and saved as a new variable in the database, called SSE (Sum of the Segments' Estimates).

In order to test whether in time perceptions “the parts do not add to the whole”, a t-test was conducted. Due to the presence of anchoring effects in Study 2 (the duration estimate for the entire experience increased when taken after the segments had been recalled), only the measures that were taken first are considered for the test (DES taken before SSE).

A t-test for equality of means showed that the duration estimate of the entire series (DES) was significantly shorter than the sum of the segments' estimates ($Mean_{DES} = 362.51$, $SD = 161.915$; $Mean_{SSE} = 436.06$, $SD = 200.24$; $t(-3.683)$; $p < .001$). This finding shows that “the parts do not add to the whole”, and they are actually greater than the whole. This can be explained because the

estimated duration of the entire series was sensitive to memory decay effects, which resulted in shortened duration estimates.

Indeed, further t-test analysis showed that memory decay increased the gap between the duration estimate for the “whole versus the parts”. Thus, that “the sum of the parts was greater than the whole” in the short delay condition ($Mean_{Short\ Delay}^{DES} = 367.72$, $SD = 157.759$; $Mean_{Short\ Delay}^{SSE} = 436.094$, $SD = 210.239$; $t(-4.122)$; $\rho < .001$) and this gap was enhanced in the long delay condition ($Mean_{Long\ Delay}^{DES} = 239.48$, $SD = 118.127$; $Mean_{Long\ Delay}^{SSE} = 426.06$, $SD = 168.743$; $t(-3.891)$; $\rho < .001$). However, “the whole did not differ from the sum of the parts” in the no delay condition ($Mean_{No\ Delay}^{DES} = 440.740$, $SD = 154.10$; $Mean_{No\ Delay}^{SSE} = 435.970$, $SD = 160.14$; $t(.181)$; $\rho = .857$).

It is also interesting to highlight that the sum of the segments’ estimate (SSE) was not affected by any of the manipulations in study 2, as shown in Tables 15.a and 15.b below. In other words, when individuals were cued to recall and estimate the duration of the different videos in the series, their measures were not affected by time delay or by when the measures were produced.

Table 15.a
ANOVA Tests (2x3 factorial design)
Dependent variable: Sum of the Segments’ Estimates (SSE)

Source	Sum of Squares	Df	Mean Square	F	Sig.
Time Condition	35204.588	2	17602.294	.441	.644
Estimate Condition	13918.238	1	13918.238	.349	.555
Time condition *	5917.870	1	5917.870	.148	.701
Estimate condition					
Error	1.070E7	268	39936.425		

Levene’s Test: $F(4,268) = 1.312$, $p = .266$

Table 15.b
Descriptive statistics for ANOVA tests
Dependent variable: Sum of the Segments' Estimates (SSE).

Time Condition	Estimate Condition	Mean (in seconds)	Std. Deviation	Sample Size
No Delay	DES taken before	435.970	160.148	34
	DES taken after	441.977	197.556	44
	Total	439.359	181.096	78
Short Delay	DES taken before	436.094	210.239	127
	DES taken after	464.615	218.354	39
	Total	442.795	211.851	166
Long Delay	DES taken before	426.060	168.743	27
	DES taken after	416.069	178.344	29
	Total	421.162	174.544	56
Total	DES taken before	436.068	200.241	188
	DES taken after	443.151	197.429	112
	Total	438.086	199.152	300

A t-test showed that subjects overestimated the true duration of the parts comprising the entire experience ($Mean_{SSE} = 438.086, SD = 198.76$; $test\ value = 383$; $t = 4.653$; $\rho < .001$). Thus, when subjects were asked to retrieve and estimate the duration of the segments comprising the experience, “the sum of the parts” was greater than the true duration of the stimuli series (clock duration= 383 seconds).

Time perception and temporal embedding

In order to test for the error of the estimates, it was necessary to compute the sum of the error of videos 1 and 4 (EV1V4) and the sum of the error of videos 2 and 3 (EV2V3) as a new variables in the database, as it was described in Chapter 4. The t-test showed no significant differences between the error of the videos embedded in the series and those which were placed at the beginning and end of the series ($Mean_{EV1V4} = .903; SD = 1.44$; $Mean_{EV2V3} = .845; SD = 1.54$; $t = .891$; $\rho =$

.374). This result is consistent with Study 1, where the sum of the errors for videos 1 and 4 was significantly lower than the error of videos 2 and 3 only when subjects were exposed to the neutral stimuli series, but not to the enjoyable ones (see Chapter 4).

Time perception and confidence bounds

Subjects were asked to produce a duration range around their best estimate for each video in the stimulus series: the shortest and longest possible duration of each video that would contain their best estimate, which is an objective measure of confidence. Given that the videos in the series have different lengths, it was necessary to compute a Duration Range Ratio (DR). This variable was calculated by dividing the difference between the longest and the shortest possible duration of each video (in seconds) by its best estimate (in seconds), as described in Chapter 4. Thus, two new variables were computed in the data base: the first representing the sum of the duration range for video 1 plus the duration range for video 4 (labelled “DRV14”), and the second representing the sum of the duration range for video 2 plus the duration range of video 3 (labelled “DRV23”). The t-test of pair comparisons showed that there is no significant difference between DRV14 and DRV23 ($Mean_{DRV14} = 1.304, SD = .700; Mean_{DRV23} = 1.257, SD = .649; t(1.319); \rho = .188$).

This result is consistent with Study 1, where only those individuals exposed to the neutral stimuli series produced a significantly lower duration range around videos 1 and 4, but those who processed the enjoyable stimuli did not differ. Thus, findings from Study 1 support results in Study 2. Participants who were exposed to the enjoyable series provided consistent judgements in Study 2: their duration estimates for videos 1

and 4 were not more accurate than the estimates elicited for the videos embedded in the series and they were not more confident about them either.

Time perception and self-assessed confidence

The subjective measure of confidence for the best estimate for each video consisted of a self-reported level of confidence. Subjects were provided with a seven-point scale and were asked to express their level of confidence that the duration range around their best estimate actually contained the true clock duration of the video (1= Not at all confident, 7= Absolutely confident). To test for self-reported confidence, the mean of the confidence level for each video was computed. T-tests showed no significant difference in self-assessed confidence ($Mean_{CONFV14} = 4.349, SD = 1.305$; $Mean_{CONFV23} = 4.451, SD = 1.238$; $t(-1.899)$; $\rho = .059$).

In sum, subjects did not feel more confident about their estimates for videos 1 and 4 relative to those videos embedded in the series when they were exposed to the enjoyable stimuli series. Moreover, their confidence bounds and the accuracy of their estimates did not differ either. These findings are also in agreement with Study 1, which were described in Chapter 4.

5.4 Summary of findings and discussion

The aim of Study 2 was threefold. First, it further explored time perceptions for a series of enjoyable stimuli. Second, it aimed to better understand the effect of memory decay on time perception. Study 2 explored whether longer time delays shorten duration estimates. Third, Study 2 examined whether time perception was affected by the order in which subjects produce their duration estimates (cueing effects). Thus, the order of the measures was counter-balanced in Study 2.

Time perception and memory decay

Study 2 investigated the effect of the effect of memory decay on the duration estimate for the stimuli series as a whole (when subjects are cued to retrieve and estimate the duration of the entire stimuli series). It was expected that longer time delays would shorten duration estimates causing subjects to underestimate time.

Findings revealed that memory decay affects time perceptions of the entire series of stimuli. The longer the delay after stimulus exposure, the shorter the duration estimates of the entire series. Moreover, memory decay shortened duration estimates when they were produced after a short delay and it provoked subjects to underestimate time when the duration estimate was elicited after a long delay. It seems plausible to say that when subjects experience memory decay they seem less able to retrieve interval filling information and to properly reconstruct the experience. Clock model literature is consistent with these findings because it assumes that time perception depends on the amount of stimulus information that individuals use to produce their time estimates.

Thus, “time flies when having fun” if the duration estimate of the entire experience is elicited after a long delay.

On the other hand, Study 2 shows that individuals overestimate the duration of the enjoyable stimuli series if they are elicited immediately after stimulus exposure. Enjoyable experiences seem to be more engaging and more richly filled with information. When subjects produce their estimates immediately after stimuli exposure, they use stimuli information that is still being kept in working memory and tend to overestimate time.

Time perception and event reconstruction

Findings illustrate that time perception for events past is affected by cueing effects during experience reconstruction. Subjects who were cued to retrieve the different segments of the stimuli series before estimating its entire duration produced higher duration estimates relative to those subjects who were cued to retrieve the experience as a whole.

Study 2 also showed that memory decay moderates cueing effects. The duration estimate for the entire stimuli series was more sensitive to memory decay when subjects were cued to recall the experience as a whole, as opposed to being cued to recall its four segments first. Subjects who were cued to estimate the duration of the entire sequence produced significantly shorter estimates in the short delay relative to the no delay condition. They strongly underestimated the entire duration of the stimuli series in the long delay condition. Thus, Study 2 illustrates that “time flies when having fun” if

individuals are cued to estimate the duration of the experience as a whole after a long delay.

On the other hand, Study 2 shows that time perception is not affected by cueing effects if individuals elicit their duration estimates immediately after stimulus exposure. In other words, the duration estimate produced for the entire stimuli series did not differ when individuals were cued to examine the stimuli either by looking at the entire experience as a whole or by examining its different subparts first. Moreover, they overestimated the duration of the enjoyable stimuli series in both treatment conditions. It seems reasonable to say that because subjects produced their duration estimates immediately after stimulus exposure, they had considerable amounts of stimulus information still in their working memory and as a consequence they overestimate time. Moreover, because the experience seems more filled-in with information immediately after stimulus exposure, cueing subjects to look at time as an entire experience or as a series of events first does not alter their time estimates.

Study 2 also illustrates that when subjects retrieved the segments of the stimuli series first, the duration estimate for the entire experience was affected by memory decay only when produced after a long delay. Thus, the experience seems more filled-in with information when individuals recall and examine its different segments before actually estimating its entire duration and this estimate is affected by memory decay only after a long delay.

Taken together, these results provide support to apply theory on event reconstruction into time perceptions research, as advanced in Chapter 2. When reviewing the literature, it was proposed that cueing subjects to recall the entire

experience elicits top-down reconstructions, but cueing them to think of the segments of the experience first elicits bottom-up event reconstructions. Individuals who are cued to perform a top-down reconstruction technique tend to recall fewer and more abstract information and consequently to underestimate time. This effect is enhanced by memory decay, when duration estimates are produced after a short and long time delay. On the other hand, individuals who are cued to perform a bottom-up reconstruction technique tend to recall more concrete information and consequently tend to overestimate time. This effect is moderated by memory decay only when duration estimates are produced after a long delay.

Time perception and “the whole (DES) versus the sum its parts (SSE)”

In Study 2, subjects were also asked to estimate the duration of each video in the stimulus series which were added up and called Sum of the Segments’ Estimates (SSE). This allowed examining time perceptions when individuals recall “the whole versus the sum of its parts”.

Study 2 showed that the duration estimate of the entire series (DES) was significantly shorter than the sum of the segments’ estimates. This finding shows that “the parts are greater than the whole”. Moreover, results show that in time perception memory decay increases the gap between “whole versus the sum of its parts”. Thus, “the sum of the parts was greater than the whole” in the short delay condition and this gap was enhanced in the long delay condition. Interestingly, the sum of the segments’ estimate was not affected by memory decay or by when the measures were produced. In other words, the gap between “the whole and the sum of its parts” is explained by the

sensitiveness of the duration estimate for the entire experience to memory decay. In sum, results show that “time flies when having fun” if subjects are cued to recall the experience as a whole after a time delay.

Time perception and temporal embedding

Study 2 showed no significant differences between the error of the first and last videos and those that were embedded in the stimuli series. This result is consistent with findings in Study 1 that pertained to enjoyable videos.

Time perception and confidence bounds

Study 2 showed no significant difference between the confidence bounds around the first and last videos and the confidence bounds around the videos embedded in the series. Participants who were exposed to the enjoyable videos provided consistent judgements in Study 2: the accuracy of the duration estimates provided for videos 1 and 4 did not differ from the estimates elicited for the videos embedded in the series and they were not more confident about them. This result is consistent with findings in Study 1 that pertained to enjoyable stimuli.

Time perception and self-assessed confidence

The self-reported level of confidence showed no significant difference between estimates for the first and last videos and those embedded in the series. These findings are in agreement with findings in Study 1 that pertained to enjoyable stimuli.

CHAPTER 6

CONCLUSIONS AND DISCUSSION

6.1 The nature of time perception

This dissertation has shown that time perceptions persistently deviate from chronological time. It has provided evidence that cognitive processes relevant to time perceptions can be distorted, leading individuals to misestimate time. When decreased amounts of attentional resources were devoted to monitoring the passage of time, duration estimates became less accurate. Memory for past durations was shown to be malleable, with duration estimates becoming shorter and/or less accurate as the distance of the event from the present increased. These findings are consistent with the traditional view to study time perceptions, which proposes that attention and memory affect the amounts of discrete interval-filling information that individuals use as cues to duration judgement, causing individuals to misestimate time (Areni and Grantham 2009; Bailey and Areni, 2006; Brown et al., 2007; Hee-Kyung et al., 2009; Zakay and Block 2004).

To extend our current understanding regarding what causes the misestimation of times past, this dissertation has provided evidence to advance that time perceptions are distorted by how individuals use interval-filling information to reconstruct a past event. In other words, time perceptions for past events were affected by cueing effects during experience reconstruction. Findings from studies 1 and 2 showed that subjects who were cued to retrieve and examine the different segments of the experience produced higher duration estimates relative to those subjects who were cued to retrieve the experience as

a whole. Moreover, Study 2 provided evidence that in time perception “the whole is not equal to the sum of its parts”. It found that time perceptions were affected by memory decay when subjects were cued to estimate the duration of the entire stimuli series. Thus, subjects who produced duration estimates after a long delay seemed to be less able to retrieve interval filling information and to properly reconstruct the experience and therefore underestimated time. On the other hand, subjects produced more accurate estimates for the entire experience after having retrieved its different subparts.

Thus, the main theoretical contribution of this dissertation advances that predicating time perception solely on the quantity of information retrieved from memory – the underlying assumption of the neural-clock model- ignores other elements inherent to the complexity of time, such as the event reconstruction process. Hence, time perceptions are also distorted by how individuals use time-filling information to reconstruct the experience, and not only on the amount of information stored in memory, as the neural-clock model proposes.

The overarching contribution of this dissertation is that time perception can be determined in a variety of ways, which in turn affect perceived duration. In light of this, the *event-reconstruction explanation* is advanced which proposes that biases enter into time-perceptions when individuals examine *how* the event took place in the past or it might take place in the future. This future research agenda is developed in Chapter 7.

6.2 Summary of findings and discussion

Time perception and attentional resources

Findings revealed that information processing distorts perception of time, and the duration estimate for the entire series of stimuli was longer and less accurate when performing active relative to passive information processing. This effect was enhanced when subjects were exposed to neutral stimuli, but not when they were exposed to the enjoyable stimuli.

Time perception and memory

This dissertation has shown that memory distorts time perceptions. When subjects recalled and estimated the duration of the entire enjoyable event, time perceptions decreased as the time delay before eliciting the measures increased. This means that cueing subjects to perform a top-down event reconstruction will shorten time perceptions as the distance of the event from present increases. Moreover, when the measures were produced after a long delay, individuals underestimated time. It seems reasonable to say that subjects who experienced memory decay seemed less able to retrieve interval filling information and to properly reconstruct the experience. Thus, there is evidence to support that “time flies when having fun” if subjects are asked to perform top-down event reconstructions after a long delay.

However, memory did not affect time perceptions when individuals recalled and estimated the parts comprising the experience. In other words, when individuals performed a bottom-up event reconstruction, the duration estimate for the sum of the

parts was not affected by the distance of the experience from present and, overall, subjects overestimated time.

On the other hand, evidence showed that regardless the event reconstruction process (either top-down or bottom-up processing), individuals overestimated the duration of the entire enjoyable experience when the measures were elicited immediately after stimulus exposure. This finding is consistent with Kellaris and Kent (1992), who found that pleasantness of musical stimuli caused subjects to overestimate time. In their study, all time perception measures were elicited immediately after stimulus exposure. Thus, they found that “time did not fly” (p.373) and suggest that music pleasantness may have motivated listeners to devote more attention to the musical excerpt and created the perception that more stimulus information was heard, which led to overestimation. Thus, enjoyable experiences seem to be more engaging and more richly filled with information and subjects who produced their estimates immediately after stimuli exposure tend to overestimate time.

Time perception and “the whole versus the sum its parts”

Study 1 showed that in time perception “the whole is greater than the sum of its parts”. This effect was enhanced (bigger gap) when duration estimates were produced after a time delay, when subjects were exposed to neutral events, and when subjects performed active stimulus information processing. These results could have been caused by anchoring effects, because the measure for how long the entire experience took was elicited after subjects had recalled and estimated the parts comprising the experience. This lack of counterbalancing was rectified in Study 2. In other words, cueing subject to

perform a bottom-up event reconstruction process lengthened the duration estimate for the experience as a whole and consequently the whole was greater than the sum of its parts. On the other hand, the whole did not differ from the sum of its parts when subjects were exposed to the enjoyable stimuli, when measures were elicited immediately after stimulus exposure, and when performing passive information processing.

In Study 2 subjects were exposed to the enjoyable stimuli series and cued to perform either a bottom-up or a top-down event reconstruction process. Bottom-up reconstructions led to overestimating the entire experience when the measures were elicited immediately or after a short delay. This result was consistent with findings in Study 1 that pertained to enjoyable videos.

When performing top-down processing, results from Study 2 showed that the duration estimate of the entire series was significantly shorter than the sum of the segments' estimates. This finding illustrates that in time perceptions for enjoyable experiences the sum of the parts is greater than the whole if subjects are cued to perform top-down reconstructions. Moreover, results showed that memory decay increased the gap between the whole and the sum of its parts. Thus, the sum of the parts was greater than the whole in the short delay condition and this gap was enhanced in the long delay condition.

Interestingly, the sum of the parts was not affected by memory decay or by when the measures were produced. However, memory decay shortened the duration estimate for the whole experience. In other words, the gap between the whole and the sum of its

parts can be explained by the effect of memory decay on the duration estimate for the entire experience. These are interesting findings because they provide support to apply literature in perceptions of events and memory psychophysics regarding reconstruction of physical objects and events (Hubbard, 1994; Kerst, 1978; Newton et al., 1977; Petrusic and Baranski, 1998; Zacks and Tverzki, 2001), into time perception research.

Time perception and temporal embedding

Study 1 illustrated that subjects' estimates for the first and last video in the stimuli series relative to those embedded in the series were more accurate when produced immediately after stimulus exposure, but not after a time delay. Moreover, the accuracy of the duration estimates for videos 1 and 4 was significantly higher than the accuracy of the videos embedded in the series when performing passive information processing, but not when performing active processing.

These findings illustrated that when performing passive processing, individuals were able to better recall and estimate the duration of the first and last video compared to those embedded in the series. However, performing active information processing helped subjects to recall all segments in the series, so that accuracy of their estimates did not significantly differ. Finally, the accuracy of the duration estimates of videos 1 and 4 was significantly higher than the accuracy of the videos embedded in the series when subjects were presented with the neutral stimuli series, but not when processing the enjoyable one.

Study 2 which examined enjoyable videos only, showed no significant differences between the error of the first and last videos and those that were embedded in the stimuli series. Thus, this result was consistent with findings in Study 1.

Taken together, findings from studies 1 and 2 provided evidence that remembered durations for the first and last segments of an experience will be more accurate than the estimates for the segments embedded between them when the measures are elicited immediately after stimulus exposure, when performing passive information processing, and when subjects are presented with a neutral stimuli series.

Time perception and event reconstruction

Findings showed that time perception for events past is affected by cueing effects during experience reconstruction. Studies 1 and 2 showed that subjects who were cued to retrieve the different segments of the stimuli series before estimating its entire duration produced higher duration estimates relative to those subjects who were cued to retrieve the experience as a whole.

Study 2 showed that memory decay moderates cueing effects for enjoyable experiences. The duration estimate for the entire stimuli series was more severely affected by memory decay when subjects were cued to recall the experience as a whole (top-down reconstruction), as opposed to being cued to recall its four segments first (bottom-up reconstruction). Subjects who were cued to estimate the duration of the entire sequence produced significantly shorter estimates in the short delay relative to the no delay condition. They strongly underestimated the entire duration of the stimuli series in the long delay condition.

Study 2 showed that the remembered duration of an enjoyable experience is not affected by cueing effects if individuals elicit their duration estimates immediately after stimulus exposure. The duration estimate produced for the entire stimuli series did not differ when individuals were cued to examine the stimuli either by looking at the experience as a whole or by examining its different subparts first. Moreover, they overestimated the duration of the enjoyable stimuli series in both treatment conditions. Subjects who produced their duration estimates immediately after stimulus exposure may have had considerable amounts of stimulus information still in working memory and as a consequence they overestimated time. Because the experience seems more filled-in with information immediately after stimulus exposure, cueing subjects to look at time as an entire experience or as a series of events first does not alter their time estimates.

Study 2 found that when subjects retrieved the segments of the stimuli series first, the duration estimate for the entire experience was affected by memory decay only when produced after a long delay. Thus, the experience seems more filled-in with information when individuals recall and examine its different segments before actually estimating its entire duration and this estimate is affected by memory decay only after a long delay.

In conclusion, there is support to apply theory on event reconstruction into time perceptions research. In Chapter 2, it was proposed that cueing subjects to recall the entire experience elicits top-down reconstructions, but cueing them to think of the segments of the experience first elicits bottom-up event reconstructions. Individuals who are cued to perform a top-down reconstruction technique tend to recall fewer and more abstract information and consequently to underestimate time. This effect is

enhanced by memory decay, when duration estimates are produced after a short and long time delay. On the other hand, individuals who are cued to perform a bottom-up reconstruction technique tend to recall more concrete information and consequently tend to overestimate time. This effect was moderated by memory decay only when duration estimates are produced after a long delay.

Accuracy and confidence in time perception

Although no theory was drawn upon to hypothesize about confidence in time estimates, the studies were designed to allow empirical investigation. Study 1 showed that subjects were more accurate and more confident in their estimates for the first and the last video relative to those embedded in the series when they produced their estimates immediately after stimulus exposure and when exposed to the neutral stimuli series. Participants were more confident about the accuracy of their estimates for the first and last videos and in fact their judgements were more veridical. Participants also produced more veridical judgements for the enjoyable videos. However, they were not more confident about their duration estimates for the first and last videos relative to those embedded in the series.

On the other hand, subjects were overconfident regarding the accuracy of their estimates in the active processing condition and when estimates were elicited after a time delay. They were also more confident when estimating the duration of the first and last video relative to those embedded in the series, but they were actually not more accurate. Finally, participants were less confident about the accuracy of their estimates

in the passive processing condition. They were not more confident about their duration estimates for the first and last videos, but they actually were more accurate.

Study 2 showed no significant difference between the confidence bounds around the first and last videos and the confidence bounds around the videos embedded in the series. The accuracy of the duration estimates provided for the first and last videos did not differ from the estimates elicited for the videos embedded in the series and they did not show a higher confidence about those estimates. This result was consistent with findings in Study 1 that pertained to enjoyable stimuli.

6.3 When does time fly?

Findings from studies 1 and 2 showed that memory for a past duration is malleable. Time perceptions lengthened when subjects performed active information processing and when the duration estimates were produced after a short delay. Indeed, subjects overestimated time when the measures were elicited immediately after stimulus exposure, regardless of cueing strategy that was used. In other words, they overestimated time when cued to recall the segments of the stimuli series (bottom-up event reconstruction) and when they were cued to recall the experience as a whole before estimating the entire duration of the experience (top-down event reconstruction).

However, Study 2 illustrated that “time flies when having fun” if the duration estimate of the entire experience is elicited after a long delay. In other words, subjects strongly underestimated time when they were exposed to the enjoyable stimuli series and they were cued to recall and estimate the entire experience (top-down processing)

after a long delay. This was an interesting finding because time did not fly when recalling the enjoyable experience immediately after stimulus exposure or after a short delay, a finding that is consistent with Kellaris and Kent (1992) and with Kellaris and Mantel (1994).

Thus, the interplay between memory and event-reconstruction process affects remembered durations for enjoyable experiences. In order to cause underestimation, it is necessary to elicit duration estimates after a long delay (in the case of Study 2, 90 minutes) and to cue individuals to perform top-down experience reconstructions.

6.4 Limitations

As with any laboratory experiment that uses university student subjects, results from studies 1 and 2 are limited by the artificial settings that were created and by the non-representative samples that were selected, which is a limitation to generalizing findings to actual marketing settings. However, an effort was made in order to use a consumption-related setting in experiments 1 and 2. For example, subjects were exposed to different fragments of TV commercials and TV shows, and they were played consecutively like any of us would switch channels at home with a remote control. Even though using a consumption-related setting does not diminish the limitation of being an artificially created scenario, it provides evidence that the findings of this dissertation can be applied to consumer behaviour settings. Thus, additional research is needed to assess how these lab findings can be generalized to other groups of consumers and marketing settings. On the other hand, the objective of this dissertation was focused on testing theory and theory development, with a special interest in a better understanding

of the cognitive processes underlying time perceptions. Thus, the experiment designs that were chosen for studies 1 and 2 were appropriate to achieve these research objectives.

Another limitation of this dissertation is the length of the stimuli series. The experiments conducted for this dissertation examined perceptions of relatively short events, which lasted for 383 seconds in total. Many consumer-related experiences involve much longer clock durations. Further research is needed to examine the influence of memory and event reconstruction processes on perceptions of longer time intervals, such as remembered events which take hours, days or weeks. For example, we know that remembered durations of how long travelling to a destination or completing a project took may affect individuals' expectations of how long the event may take in the future and their decisions regarding whether or not they want to engage in the same activity again (Ettema *et al.*, 2004; Zimbardo and Boyd, 1999). Future research could therefore examine the influence of memory and event reconstruction processes on time perceptions of longer events.

An additional limitation is that the experiments in this dissertation did not manipulate level of abstract/concrete information processes. In other words, studies 1 and 2 cued the subjects to recall the entire experience (top-down reconstructions) and/or to think of the segments of the experience first (bottom-up reconstructions), but they did not test or manipulate the level of abstractness/concreteness of the information that individuals used when estimating time. A possible explanation was advanced, for some of the findings, that individuals who are cued to perform a top-down reconstruction tend to recall fewer and more abstract information and consequently to underestimate time or to say that individuals who are cued to perform a bottom-up reconstruction process tend

to recall more concrete information and consequently to overestimate time. Thus, further experiments should also manipulate abstract versus concrete information processing in order to examine if they cause individuals to misestimate time.

Finally, this dissertation examined cognitive processes underlying time perceptions for events past, but not their consequences on consumers' decision making processes. In other words, studies 1 and 2 manipulated different cognitive processes and elicited several measures of remembered durations, but subjects were not asked to manifest any intended behavioural responses, such as willingness to watch the TV show again or to spend more time watching it the next time. Future studies should examine consumption-relevant outcomes of remembered durations such as satisfaction judgements or behavioural intentions. The literature that was reviewed in Chapters 1 and 2 offered abundant evidence to support that time perceptions have profound ramifications on consumer behaviour, and showed that marketing researchers have dedicated considerable effort to understanding the effects that time perceptions play in consumers' decision-making. However, the main research gap pointed to a "lack of theoretical development" (Bettany & Gatrell, 2009), the need for a better comprehension of how cognitive processes can affect time perceptions, and how marketers may therefore cue customers on how to perceive time to their own benefit. This dissertation attempted to fill that gap.

6.5 Managerial Implications

Implications to marketers regarding misestimation of time are straightforward. Marketers may wish to reduce consumers' perceptions of elapsed times (i.e., watching a TV show that is interrupted by a commercial, web downloading times, waiting in line, etc.), or they may wish to increase elapsed time perceptions (i.e., time spent with the family or leisure time). According to Bailey and Areni (2006), marketers seem to have a general understanding of the benefits of using atmospheric music or television programming at queuing points, where the objective is to distract customers from monitoring the passage of waiting time; but they seem to be much less aware of the potential counterproductive effects of these measures (such as an increased perception of the time spent waiting if customers consider how many songs they listened to). Findings from this dissertation show how to mend this oversight.

For example, Study 1 showed that subjects overestimated the entire duration of the enjoyable stimuli series when performing active and passive processing, and these estimates did not significantly differ. In other words, distracting subjects from monitoring the passage of time by using enjoyable stimuli did not make time fly because they were cued to examine each video before estimating the duration of the entire session. This result represents Bailey and Areni's scenario about producing increased estimates for waiting times after considering the number of songs listened to. On the other hand, Study 2 showed that marketers can reduce overestimation of an interval filled with enjoyable stimuli if individuals are unable to quantify its distinct events. According to Study 2, this can be achieved if subjects are cued to perform top-down event reconstructions after a short delay (i.e., 5 minutes) or after a long delay (i.e.,

90 minutes). Using unfamiliar stimuli also helps to achieve this objective, because they are less distinctive and harder to use as cues to duration judgements.

Marketers may also be interested in shortening time perceptions when making decisions about television programming. Television programming has commercial breaks, and we know that viewers are relatively knowledgeable regarding the clock duration of these breaks (Webb, 1979). In studies 1 and 2 the enjoyable stimuli series alternated fragments of a TV show and a TV ad in a sequential order (see Table 4 in Chapter 4). If viewers become more aware of the number and duration of the commercial breaks within the TV show (bottom-up processing), time perception for the time spent watching the program will increase; but if they become less able to distinguish the commercials (top-down processing), the duration estimate for time spent watching the entire TV program will decrease. Moreover, time perception for the time spent watching the entire program will be shorter if they are produced after a 5-minute delay and will be strongly underestimated after a 90-minute delay. Thus, marketers would be able to reduce or eliminate the counterproductive effects of the amount of commercials that viewers may use as cues to duration judgement.

The last example is related to time-consuming activities. Consumers have been shown to engage in consumption of time-saving products or in different time-consuming activities in order to take more control of their leisure and family times (Bettany & Gatrell, 2009). These authors found that rather than being slaves to time scarcity, professional dual career parents actively “speed up” and “slow down” time through particular consumption practices. They provide an example of how fathers slow down time related to food consumption. Fathers seemed happier to be involved with and

enjoyed the preparation of some meals as part of parenting, which became time linked consumption practices. Using the concepts examined in this dissertation, it is a nice example of how thinking of the parts comprising the experience makes the whole seem longer. A father explains (pp. 296):

What I do enjoy is at the weekend there is a market in the town, often a French market and we go down and choose nice veg and go to the butchers for meat and the deli for nice bits then I cook a lovely meal for the family on Saturday evening. It is a special time now that they are getting a little bit older. They learn about things...what kind of things err well...we were looking at celeriac, it is so ugly why would you want to eat it but it tastes lovely so you have to get them over the ugliness of it...they did eat it (laughter) it is important that they understand how...how to eat actually (James, Senior Manager)

Moreover, the authors conclude that the fathers, like James above, actively sought these time linked consumption practices as a way to significantly develop the parent-child relationship. “They were not slowing time to do *less*, but slowing time to do *more*” (pp. 296). In other words, consumers want these enjoyable family times to last longer. This dissertation has shown that a series of enjoyable events seems longer in retrospect when subjects recall and examine each part comprising the experience. Study 2 showed that the sum of the parts is greater than the whole. Moreover, the duration estimate for the sum of the parts was not affected by the distance of the experience from present and overall, individuals overestimated time. Thus, marketers should encourage consumers to remember and to estimate how much time the family spent on each one of the enjoyable activities comprising the whole. They will perceive that the enjoyable family experience was more richly filled with events and regardless of how long ago it took place, they will therefore overestimate its true duration.

In summary, results from studies 1 and 2 found grounds to propose that individuals not only consider discrete information, but also different event reconstruction techniques as cues to duration judgement. In contrast, but not necessarily to the exclusion of the neural-clock model, the next chapter advances a more comprehensive and explanatory approach to the study of time perception. It proposes that time perceptions are affected by both the *hierarchy* and the *temporal distance* of the events that individuals recall and use as clue to duration judgements.

CHAPTER 7

AVENUES FOR FURTHER RESEARCH

“It is not the number of years in your life what matters, but the life in your years”
Abraham Lincoln

7.1 A new paradigm to study time perceptions

The neural-clock model proposes that our neural system generates and stores individual pieces of information which represent experienced events, like an individual would take photographs of a vacation and keep them in a photo album (Kundera, 1999). When recalling past events, individuals retrieve these photographs and use them as a proxy to duration judgement. Individuals who recall a great number of time-filling information tend to perceive that the event took longer than it actually did. (Brown et al., 2007; Hee-Kyung et al., 2009; Zakay and Block 2004). The neural-clock model consistently offers, throughout more than a hundred years of research, a “discrete-information explanation” for misestimating time: longer duration judgements are associated with more interval-filling information being recalled from memory and vice versa.

Using two experimental studies, this dissertation found grounds to propose that individuals not only consider discrete information, but also different event reconstruction techniques as cues to duration judgement. In contrast, but not necessarily to the exclusion of the neural-clock model, this chapter advances the foundations for a more comprehensive and explanatory approach to the study of time perception. It proposes that time perceptions are affected by both the *hierarchy* and the *temporal distance* of the events that individuals recall and use as clue to duration judgements.

Implications to marketers are straightforward: it is during interpretation and comprehension that biases enter into perception. In some instances, marketers may wish to reduce consumers' perceptions of elapsed times (web downloading times, driving to location, waiting in line, etc.), while in others they may wish to increase elapsed time perceptions (park rides, holidays or experienced services). Marketers may therefore be able to cue customers on how they reconstruct past events and construct future events to their own benefit.

The event reconstruction explanation that is advanced here proposes that biases enter into time perceptions when individuals interpret *how* the event took place in the *past* or it might take place in the *future*. It is important to note that literature pertaining to event reconstruction rarely makes a connection between how an event is interpreted and how this would affect perception of time. Hence, the following is an original contribution that appears to be well grounded both theoretically and empirically (i.e., findings from Study 1 and Study 2 showed that top-down and bottom-up event reconstruction techniques elicited different duration estimates for the entire experience). Herein, I propose that event reconstruction may account for much of the error in time perception across a wide variety of marketing settings. It provides plausible explanations of why individuals misestimate time and of when it is likely to happen. This perspective provides rich avenues for further research.

7.2 Time perception and event reconstruction

The event reconstruction explanation for misestimating time that is advanced in this section is consistent with Graham (1981) who refers to perception of time as varied

organizations of reality which are fed by cues taken from the environment; and with Zimbardo and Boyd (1999) who take time perceptions as an often unconscious process whereby social experiences are assigned to temporal categories, which help give order and meaning to those events. It is also consistent with Zacks and Tversky (2001, pp.3) who define an event as “a segment of time at a given location that is conceived by an observer to have a beginning and an end”; and event structure is taken as “the process by which observers identify these beginnings and endings and their relationships”. Two concepts relevant to the event structure perspective are the *hierarchy* and the *temporal distance* of the events that individuals recall and use as clue to duration judgements.

Event-hierarchy explanation

The event-hierarchy explanation for misestimating time refers to the identification of logical relations among event components. It seeks to understand how relations within event components constitute cues to duration judgements. According to Zacks and Tversky (2001), events can be viewed as being organized in parts and sub-parts (partonomic relationships), categories representing their intrinsic properties (taxonomic relationships) and causal relationships.

Event partonomies look at how people segment an activity as it happens. Chapter 2 illustrated the “taking family to the theme park” event, which may consist of sub-parts that build-up to a whole: “buying tickets online”, “getting in the car”, “driving to destination”, “parking” and “walking to the entrance”. In this case, individuals perceive events as organized into partonomic hierarchies: subordinate (i.e., getting in the car), basic (i.e., driving to destination) and superordinate (i.e., taking family to the park). Individuals tend to conduct bottom-up inferences when cued with subordinate-

level actions, but show great trouble at making downward inferences to the subordinate level when cued with superordinate information (Abbot et al. 1985). This means that individuals tend to judge events using more subordinate rather than superordinate information. Moreover, focusing on superordinate events elicits a more abstract level of information processing compared to subordinate events.

Event taxonomy is a hierarchy that classifies events based on “kind of” rather than “part of” relationships. For example, the event “screaming on the roller coaster” may be categorized as subordinate (ride), basic (theme park), or superordinate (entertainment). As for partonomic relations, Zacks and Tversky (2001) state that there is a tendency to identify more events at the basic level and abstract processing increases from the subordinate to superordinate categories. Moreover, perception of similarity also increases from the subordinate to the superordinate category (Morris and Murphy 1990). For example, “taking family to the theme park” and “taking family to the movies” are likely to be perceived as more similar (they are both superordinate activities, entertainment) compared to how similar “screaming on the roller coaster” and “laughing at the movies” would be judged (they are both subordinate activities).

Taken together, event-partonomy and event-taxonomy can be used to evoke either abstract or concrete information processing modes. For example, Malkoc *et al.*, (2007) in a series of three experiments engage subjects in tasks that evoked either abstract or concrete information processing modes. A subsequent task told them to assess an imaginative future scenario. Individuals previously engaged in abstract information processing modes were less specific and less present-oriented when considering the following task than those previously engaged in concrete information processing.

Graziano *et al.*, (1988) find that individuals cued about the subject of a videotape before watching it produce larger subparts of the video.

Thus, event-partonomy and event-taxonomy are believed to represent rich sources of biases to time perceptions. The event-hierarchy explanation proposes that time perceptions are affected by the strategies that individuals use to construct events. Individuals are expected to produce fewer but more abstract subparts when induced to perform top-down processing, which would shorten perceptions of time. On the other hand, individuals are expected to produce more concrete subparts when using the bottom-up technique, which will lengthen time perceptions. It also advances that perception of events' similarity/dissimilarity biases time perceptions. In this regard, the neural-clock paradigm does not provide predictions because it does not acknowledge hierarchy in events. Taken together, these studies suggest that individuals may thoughtfully and purposively filter some time-relevant information. Thus, we state as propositions for further research:

Proposition 1: Time perception of a target interval is shorter when performing a top-down relative to a bottom-up event-construction.

Proposition 2: For events of the same chronological length, variability in time perceptions decreases as perceptions of event-similarity increases.

Finally, causal event-relationships refer to the perception that an event has been triggered by the action of another one. Consistent with Michotte (1963), Zacks and Tversky (2001) use the illustration of the billiard ball hitting another: causality is characterized by the phenomenon of “transference of motion from one object to

another”, which takes place when the motion of the launcher is projected into the launchee. Interestingly, the authors predict (but do not test) that the most causally loaded moments within an event would be the points at which individuals tend to subdivide the event (breakpoints), because it is there when most of the physical change occurs.

The event-causality explanation for misestimating time advances that causal relations bias duration judgements. The “transference-of-the-motion” effect is expected to elicit perceptions of longer durations if the causal target-event “prolongs” itself into the following event. Evidence supporting the event-causality explanation is provided by Diehl *et al.*, (2007). Past interval-durations were affected by the number of events perceived as being caused by a beginning event, so that the greater the number of subsequent events, the longer the perceived duration of the entire past time-interval. Thus, stated as proposition for further research:

Proposition 3: Time perception of a target interval will be longer when the target event is believed to positively affect the actions of subsequent events.

Temporal-distance explanation

Temporal distance is taken as the remoteness of the event from present. For example, the event “taking family to the theme park” may have happened either last weekend or a month ago, but can also be placed in the future, as you may plan to go this Saturday or in five weeks time. The temporal-distance explanation for misestimating time advances that time perceptions are likely to be biased by temporal remoteness of the event from present.

We know that the temporal distance of events from present affects the type of salient information that individuals consider when judging duration estimates. People tend to divide events at breakpoints where physical changes of even-features concentrate; they also tend to use these breakpoints for event-identification purposes (Newtson and Engquist, 1976; Newtson *et al.*, 1977). However, there seems to be a limited temporal distance within which individuals are able to naturally perceive these event breakpoints. Zacks and Tversky (2001) propose that for brief clock durations, such as a few seconds, individuals tend to perceive events in terms of *physical changes*; for intervals lasting from a few minutes to a few hours, events seem to be characterized by *goals or plans*; and for longer intervals, events are more likely *thematically* characterized. For example, describing the event “catching the bus”, is likely to be divided into “approaching the bus”, “stepping-up” and “finding a seat”, all physical changes. But catching the bus may be part of an event of a longer time interval such as “going to school”. Even this event may be part of a much larger event called “acquiring an education”. Generally, the kinds of event-features which are more salient as the time intervals increase tend to vary from physical-features to more goal, plan and thematic oriented.

Supporting these arguments, evidence shows that thinking of events placed in the near future/past versus in the far future/past elicits more concrete mental representations of the events (Malkock and Zauberman, 2006) and the type of goals people value (Mogilner et al., 2008, Liu and Aaker, 2007). When time is expansive, people tend to put more emphasis on learning goals (Carstensen *et al.*, 1999); when it is limited or coming to an end, individuals emphasize more emotionally meaningful goals (Williams and Drolet, 2005). On the other hand, research on inter-temporal decisions shows that people are biased towards near-future events (Thaler, 1981), so they tend to

prefer a sooner, smaller outcome over a later, larger one; but this effect decreases as the temporal distance of the event increases (hyperbolic discounting). More interesting, Zauberman et al. (2008, 2009) found that present bias seems to be mitigated when discount rates are calculated with subjective times: a delay from three to six months in receiving a gratification deserves a greater discount rate than is the same three month delay from six to nine months. This last case could be explained by a shorter subjective duration being produced for the three month delay placed in the far future.

Consumers have also been shown to judge pairs of events to seem more similar in the distant future and past, but more dissimilar in the near future and past (Day & Bartels, 2009). A new-product-launch event that is placed in the past looks different when considered as a forthcoming event, and it alters the type of salient information that individuals seek and pay attention to (Jung-Grant & Tybout, 2003).

Applying these biases in perceptions of distant/near events into time perception research, I advance a temporal-distance explanation for misestimating time. The temporal distance of an event from present is expected to distort time perceptions because the type and amount of salient event-features change as individuals move from short to long time distances. Because events placed in the near past/future can be richly described, individuals attach more concrete information to them and are more likely to overestimate time. On the other hand, events taking place in the distant past or far future are better described in terms of abstract and thematic information which more likely leads to underestimation. Evidence from Study 2 is consistent with this statements, although any future study to test for these propositions would need to measure the type of information processing (abstract versus concrete) evoked by subjects given various time delays.

To the author's knowledge, the neural-clock model has only been tested over short time intervals (chronological durations vary from milliseconds to at most a few minutes). Considering that these intervals are expected to be filled-in with more discrete and physical information, it seems reasonable to accept the neural-clock model within this brief clock durations, either for prospective or past times. For events placed in the far future/past, the temporal-distance explanation would postulate that:

Proposition 4: Time perception of a target interval that is placed in the far future/distant past is likely to be filled with more abstract relative to concrete information and consequently underestimated.

7.3 Discussion and conclusion

This chapter advances the event-structure perspective as a more explanatory and comprehensive theoretical approach to study time perceptions in consumer research. In contrast to, but not necessarily to the exclusion of the neural-clock model, it proposes that misestimating time can also be explained by the type of information that individuals use to structure and interpret events.

This work finds evidence to advance two dimensions relevant to event-structure, hence perceptions of time: hierarchy and temporal distance. These are presented as a starting point to theory development. Event-hierarchy examines how both hierarchical and causal relationships among events may either shorten or lengthen duration estimates. Temporal distance advances how the remoteness of an event from present in the time continuum affects the type of event-salient information that individuals are

more likely to perceive, which in turn affects duration estimates. These dimensions are expected to play a critical role when:

- i) individuals estimate durations of times past, because individuals reconstruct the target event;
- ii) individuals perceive the passage of time while elapsing, because they form scenarios using information stored in working memory; and
- iii) individuals predict durations, because individuals imagine and structure how the event may take place in the future.

Taken together, the overarching proposition of the event-reconstruction explanation is that the type of bottom-up or top-down processing that individuals use to construct the event is expected to impact the level of abstractness/concreteness of the information that individuals evoke. In other words, time perceptions are biased by both quantity of information and level of information abstractness/concreteness. Several issues become apparent and relevant from the event-structure explanation:

First, presenting an event as a sequence of subparts elicits a partonomic bottom-up construction-process, which increases the amount of concrete event-information that individuals use for characterizing it. Hence, the perceived durations of all subparts are not likely to add to the whole and individuals overestimate time. On the other hand, using top-down construction processes makes the sequence harder to discern an underlying rhythm and the event's natural breakpoints become less noticeable. As a result, top-down processing primes more abstract information and time perceptions are shortened.

Second, events can be structured by establishing hierarchical relations among them. Subordinate events are more easily characterized by natural breakpoints, but individuals seem to have trouble trying to identify natural breakpoints within superordinate events. This means that superordinate events are more likely to be filled with more abstract information than subordinate ones. In this sense, abstractness could be defined as “the absence of natural breakpoints”. Consequently, focusing on superordinate events elicits a more abstract level of information processing compared to subordinate events and time perceptions shorten. When cause-effect relations among consecutive subparts are triggered by a common initial event (motion effect), perceptions of time for the entire interval are expected to lengthen.

Third, there seems to be a limited range of time scales within which individuals are able to accurately perceive event breakpoints. As the remoteness of the event from present increases natural breakpoints seem to fade and become hard to discern, which elicits more abstract information processing. Perceived durations of the same event-interval are expected to decrease as its remoteness from present increases.

Finally, while the aforementioned event-reconstruction perspective requires empirical verification, it is believed that an important step has been made towards setting the foundations for more comprehensive theory development and a more refined understanding of why time perceptions systematically deviate from chronological time.

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APPENDIX 1



**Research Project:
People's reactions to audiovisual stimuli**

BUHREC Protocol number: RO-936

Research Investigators and Contact Details:

Sonia Vilches-Montero
PhD Student. Faculty of Business, Technology and Sustainable Development
Bond University, Gold Coast. QLD 4229
Telephone Number: 07-5595 2206
Email Address: svilches@bond.edu.au

Associate Professor Dr. Mark Spence
Faculty of Business, Technology and Sustainable Development
Bond University, Gold Coast. QLD 4229
Telephone Number: 07-5595 2276
Email Address: mspence@bond.edu.au

Explanatory Statement:

Thanks for participating in this study. The purpose of this research is to test people's reactions and feelings while exposed to different types of audio-visual stimuli.

Participants are to be Bond University students aged between 18-30 years-old. Participation in the study will take approximately 30 minutes and is entirely voluntary. You are not obliged to participate and you can withdraw at any time without penalty or explanation.

Your responses will be kept anonymous. Your name is required on this page only for you to receive course credit for completing the questionnaire. When you turn in the questionnaire, **please separate these first 2 pages** from the rest of the questionnaire so that your name will never be connected to your responses. All data will be stored securely for five years, in accordance to Bond ethical guidelines.

Should you have any complaints concerning the manner in which the research is conducted, please do not hesitate to contact Bond University Research Ethics Committee, quoting protocol number RO-936.

Ethics Officer Complaints
Bond University Human Research Ethics Committee
Bond University Research and Consultancy Services
Level 2, Central Building
Bond University QLD 4229
Telephone (07) 5595 4194 Fax (07) 5595 1120
Email: buhrec@bond.edu.au

This questionnaire will be completed while you are shown a series of four video-tapes. There are no right or wrong answers to the questions, so please answer the questions thoughtfully and honestly. It is important that you **answer every question**.

Once again, thanks for your help.
Sincerely,

Sonia Vilches-Montero

Your name is: _____ (only used for credit in completing this task)

Instructions

You are going to see a series of 4 videos. They are related to daily-life episodes that you might watch or experience during a normal day. After seeing the videos, you will be asked to answer questions related to them. There are no wrong or right responses, but it is important for the study that you try to do your best when answering questions. Please answer every question honestly and thoughtfully.

The questions that you will be asked are related to the following topics:

- Sponsors mentioned or shown in the video
- The main message or content of the video

Please try to keep these topics in mind while you are shown the videos, so you will be able to recall information when answering the questionnaire. Do not write down information on this booklet, just keep it in mind.

Please do not turn the page until you have already seen all of the video-tapes. Do not start writing your answers until you are asked to.

(Start playing videos)

Stop, the video tapes have now finished. Please do not proceed to read next page until you are asked to; we need all of the participants to start at the same time.

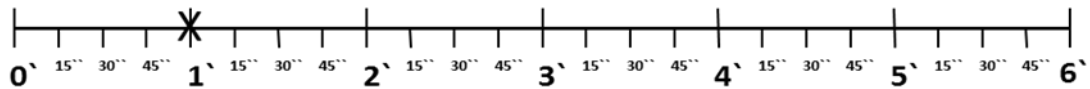
Please answer the questions presented below.

1. How many different people did ask for help in video 1: “Hidden camera”?

2. How many people were shown in Video 2: “Monkeys in suits”?

3. What company is the sponsor of the car advertisement?

4. Now you will be asked to estimate the duration of each video (in minutes, seconds) and the duration-range in which your estimate should be included. Use the ruler presented below to write down your time estimates, considering minutes and seconds. For example, if you consider that the video lasted 60 seconds, then write down an X on the ruler as shown below:

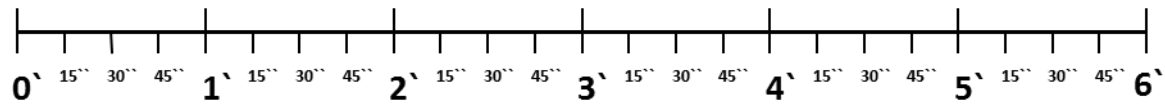


In this case 60 seconds is your best estimate. Then estimate both a lower and upper limit for your best estimate. For example, if you estimate that the shortest possible duration of the video is 30 seconds and the longest possible one is 75 seconds, then write down an X on the ruler as shown below:

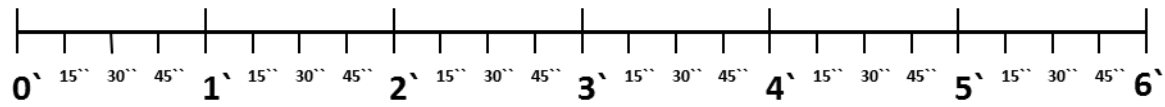


You can choose whatever position you want on the ruler, but please do your best when estimating time durations and try to make the range as small as possible.

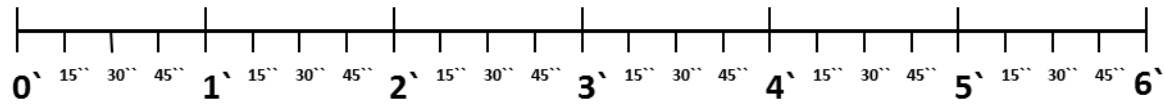
Video 1: Hidden camera



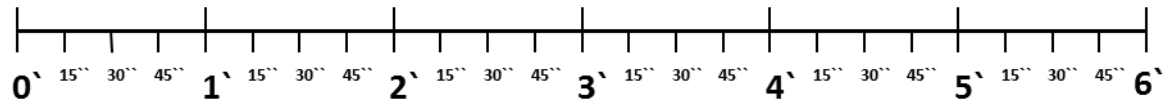
Video 2: Monkeys in suits



Video 3: Comedians



Video 4: Car advertisement



5. How confident are you that the shortest and longest durations that you provided actually include the true duration of the video?

Video 1

Not at all confident	1	2	3	4	5	6	7	Extremely confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 2

Not at all confident	1	2	3	4	5	6	7	Extremely Confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 3

Not at all confident	1	2	3	4	5	6	7	Extremely Confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 4

Not at all confident	1	2	3	4	5	6	7	Extremely confident
-------------------------	---	---	---	---	---	---	---	------------------------

6. Without looking to your previous estimates, how long do you think to see the four videos took? Do not consider any gaps or interruptions between videos.

7. Overall, how do you rate how entertaining the 4 videos were?

BORING	-3	-2	-1	0	+1	+2	+3	FUNNY
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8. Without looking at the previous page, please write down your time estimates again, in the table presented below. Use Numbers to represent time durations. For example, if you estimate that the first video lasted 1 minute, write 1:00 on the corresponding cell; if you consider the estimate to be 1 minute and 10 seconds write 1:10 on the cell.

	SHORTEST POSSIBLE DURATION	BEST ESTIMATE	LONGEST POSSIBLE DURATION
VIDEO 1			
VIDEO 2			
VIDEO 3			
VIDEO 4			

9. When estimating time durations, which type of measure do you think it was easier to understand and apply the ruler or the table?

Easier to understand:

Ruler ☐

Table ☐

Easier to apply:

Ruler ☐

Table ☐

10. What is your gender?

Male ☐

Female ☐

11. What is your Citizenship? _____

The survey is now complete. Many thanks for your help.

Research Project:
People's reactions to audiovisual stimuli

B

BUHREC Protocol number: RO-936

Research Investigators and Contact Details:

Sonia Vilches-Montero
PhD Student. Faculty of Business, Technology and Sustainable Development
Bond University, Gold Coast. QLD 4229
Telephone Number: 07-5595 2206
Email Address: svilches@bond.edu.au

Associate Professor Dr. Mark Spence
Faculty of Business, Technology and Sustainable Development
Bond University, Gold Coast. QLD 4229
Telephone Number: 07-5595 2276
Email Address: mspence@bond.edu.au

Explanatory Statement:

Thanks for participating in this study. The purpose of this research is to test people's reactions and feelings while exposed to different types of audio-visual stimuli.

Participants are to be Bond University students aged between 18-30 years-old. Participation in the study will take approximately 30 minutes and is entirely voluntary. You are not obliged to participate and you can withdraw at any time without penalty or explanation.

Your responses will be kept anonymous. Your name is required on this page only for you to receive course credit for completing the questionnaire. When you turn in the questionnaire, **please separate these first 2 pages** from the rest of the questionnaire so that your name will never be connected to your responses. All data will be stored securely for five years, in accordance to Bond ethical guidelines.

Should you have any complaints concerning the manner in which the research is conducted, please do not hesitate to contact Bond University Research Ethics Committee, quoting protocol number RO-936.

Ethics Officer Complaints
Bond University Human Research Ethics Committee
Bond University Research and Consultancy Services
Level 2, Central Building
Bond University QLD 4229
Telephone (07) 5595 4194 Fax (07) 5595 1120
Email: buhrec@bond.edu.au

This questionnaire will be completed while you are shown a series of four video-tapes. There are no right or wrong answers to the questions, so please answer the questions thoughtfully and honestly. It is important that you **answer every question**.

Once again, thanks for your help.
Sincerely,

Sonia Vilches-Montero

Your name is: _____ (only used for credit in completing this task)

Instructions

You are going to see a series of 4 videos. They are related to daily-life episodes that you might watch or experience during a normal day. After seeing the videos, you will be asked to answer questions related to them. There are no wrong or right responses, but it is important for the study that you try to do your best when answering questions. Please answer every question honestly and thoughtfully.

The questions that you will be asked are related to the following topics:

- Sponsors mentioned or shown in the video
- The main message or content of the video

Please try to keep these topics in mind while you are shown the videos, so you will be able to recall information when answering the questionnaire. Do not write down information on this booklet, just keep it in mind.

Please do not turn the page until you have already seen all of the video-tapes. Do not start writing your answers until you are asked to.

(Start playing videos)

Stop, the video tapes have now finished. Please do not proceed to read next page until you are asked to; we need all of the participants to start at the same time.

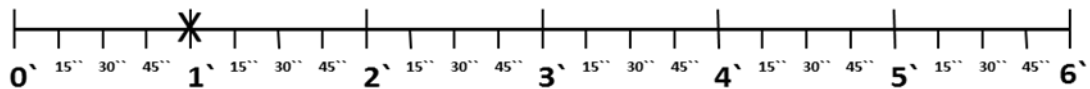
Please answer the questions presented below.

1. How many different people spoke in video 2: “Trade indicators”?

2. How many people were shown in Video 3: “Tunnel Crossing”?

3. What company is the sponsor of the car advertisement?

4. Now you will be asked to estimate the duration of each video (in minutes, seconds) and the duration-range in which your estimate should be included. Use the ruler presented below to write down your time estimates, considering minutes and seconds. For example, if you consider that the video lasted 60 seconds, then write down an X on the ruler as shown below:

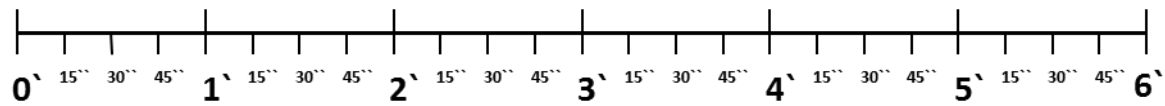


In this case 60 seconds is your best estimate. Then estimate both a lower and upper limit for your best estimate. For example, if you estimate that the shortest possible duration of the video is 30 seconds and the longest possible one is 75 seconds, then write down an X on the ruler as shown below:

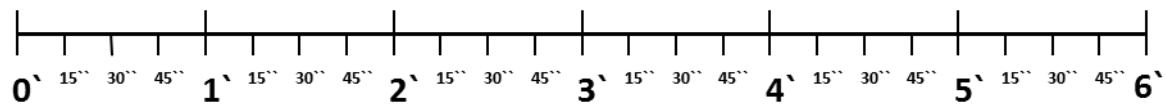


You can choose whatever position you want on the ruler, but please do your best when estimating time durations and try to make the range as small as possible.

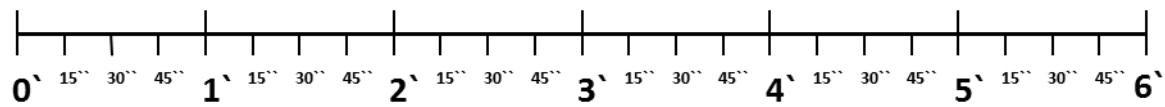
Video 1: Speech



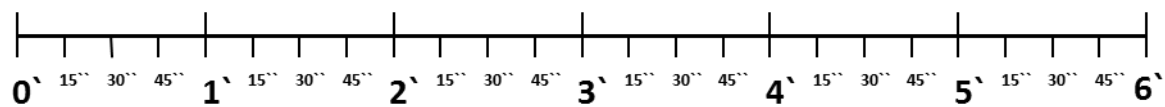
Video 2: Trade Indicators



Video 3: Tunnel Crossing



Video 4: Car advertisement



5. How confident are you that the shortest and longest durations that you provided actually include the true duration of the video?

Video 1

Not at all confident	1	2	3	4	5	6	7	Extremely confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 2

Not at all confident	1	2	3	4	5	6	7	Extremely Confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 3

Not at all confident	1	2	3	4	5	6	7	Extremely Confident
-------------------------	---	---	---	---	---	---	---	------------------------

Video 4

Not at all confident	1	2	3	4	5	6	7	Extremely Confident
-------------------------	---	---	---	---	---	---	---	------------------------

6. Without looking to your previous estimates, how long do you think to see the four videos took? Do not consider any gaps or interruptions between videos.

7. Overall, how do you rate how entertaining the 4 videos were?

BORING	-3	-2	-1	0	+1	+2	+3	FUNNY
---------------	----	----	----	---	----	----	----	--------------

8. Without looking at the previous page, please write down your time estimates again, in the table presented below. Use Numbers to represent time durations. For example, if you estimate that the first video lasted 1 minute, write 1:00 on the corresponding cell; if you consider the estimate to be 1 minute and 10 seconds write 1:10 on the cell.

	SHORTEST POSSIBLE DURATION	BEST ESTIMATE	LONGEST POSSIBLE DURATION
VIDEO 1			
VIDEO 2			
VIDEO 3			
VIDEO 4			

9. When estimating time durations, which type of measure do you think it was easier to understand and apply the ruler or the table?

Easier to understand:

Ruler ☐

Table ☐

Easier to apply:

Ruler ☐

Table ☐

10. What is your gender?

Male ☐

Female ☐

11. What is your Citizenship? _____

The survey is now complete. Many thanks for your help.

APPENDIX 2

**Research Project:
People's reactions to audiovisual stimuli**

AX1

BUHREC Protocol number: RO-936

Research Investigators and Contact Details:

Sonia Vilches-Montero

PhD Student. Faculty of Business, Technology and Sustainable Development

Bond University, Gold Coast. QLD 4229

Telephone Number: 07-5595 2206

Email Address: svilches@bond.edu.au

Associate Professor Mark Spence

Faculty of Business, Technology and Sustainable Development

Bond University, Gold Coast. QLD 4229

Telephone Number: 07-5595 2276

Email Address: mspence@bond.edu.au

Explanatory Statement:

Thanks for participating in this study. The purpose of this research is to assess people's reactions and feelings while exposed to different types of audio-visual stimuli. Participation in the study will take approximately 30 minutes and is entirely voluntary. You are not obliged to participate and you can withdraw at any time without penalty or explanation.

Your responses will be kept anonymous. Your name is required only for you to receive course credit for completing the questionnaire. When you turn in the questionnaire, **please separate this page from the rest of the questionnaire** so that your name will never be connected to your responses. All data will be stored securely for five years, in accordance to Bond ethical guidelines.

Should you have any complaints concerning the manner in which the research is conducted, please do not hesitate to contact Bond University Research Ethics Committee, quoting protocol number RO-936:

Ethics Officer Complaints

Bond University Human Research Ethics Committee

Bond University Research and Consultancy Services

Level 2, Central Building

Bond University QLD 4229

Telephone (07) 5595 4194 Fax (07) 5595 1120

Email: buhrec@bond.edu.au

Once again, thanks for your help.

Sincerely,

Sonia Vilches-Montero

Dr. Mark Spence

Your name is: _____ (this is collected so that you may receive course credit)

Instructions

You are going to see a series of four videos. They relate to daily-life episodes that you might watch or experience during a normal day. After seeing the videos, you will be asked to answer questions related to them. Please answer every question honestly and thoughtfully.

Some of the questions that you will be asked are related to the following topics:

- Sponsors mentioned or shown in the video
- The main message or content of the video

Please try to keep these topics in mind while you are shown the videos, so you will be able to recall information when answering the questionnaire. Do not write down information on this booklet, just keep it in mind.

**Please do not turn the page until you have seen all of the video-tapes.
Do not proceed until you are asked to.**

(Start playing videos)

The first question is not related to the videos. Instead, the researcher will give you a few minutes to see how many cities you can name starting with a city that begins with the letter A (for example, Adelaide), then B (for example, Beijing), and so forth. Name one city for each letter. If you cannot think of a city that begins with that letter, move on to the next letter. You may start immediately.

Name a city that begins with the letter:

A _____

B _____

C _____

D _____

E _____

F _____

G _____

H _____

I _____

J _____

K _____

L _____

M _____

N _____

O _____

P _____

Q _____

R _____

How many cities did you name? _____

Stop. Please do not turn the page until instructed to do so.

Please answer the questions presented below.

1. How many people were shown in the video “Monkeys in suits”?

2. What company is the sponsor of the car advertisement?

3. How many different people did ask for help in the “Hidden camera” video?

4. Now you will be asked to estimate the duration of each video in minutes and seconds. To do so, please first provide your BEST ESTIMATE. How long do you think the video lasted? After doing so, we would now like you to put a range about that estimate: what is the shortest time the video could have lasted and what is the longest time? Thus, if you thought the video lasted 2:10 (two minutes and 10 seconds), but could have been as short as 2:00 (two minutes and 0 seconds) and as long as 2:30 (two minutes and 30 seconds), you would fill-in the row like:

	BEST ESTIMATE	SHORTEST POSSIBLE DURATION	LONGEST POSSIBLE DURATION
<u>VIDEO</u>	2:10	2:00	2:30

Please try to and keep your range as small as possible, but do your best to make sure the actual length of the video falls between the shortest and longest possible duration.

	BEST ESTIMATE	SHORTEST POSSIBLE DURATION	LONGEST POSSIBLE DURATION
<u>VIDEO 1:</u> Hidden camera			
<u>VIDEO 2:</u> Monkeys in suits			
<u>VIDEO 3:</u> Comedians			
<u>VIDEO 4:</u> Car Advertising			

5. With respect to the time estimates you provided above, how confident are you that the shortest and longest durations that you provided actually include the true duration of the video?

Video 1

Not at all Confident	1	2	3	4	5	6	7	Extremely Confident
----------------------	---	---	---	---	---	---	---	---------------------

Video 2

Not at all Confident	1	2	3	4	5	6	7	Extremely Confident
----------------------	---	---	---	---	---	---	---	---------------------

Video 3

Not at all Confident	1	2	3	4	5	6	7	Extremely Confident
----------------------	---	---	---	---	---	---	---	---------------------

Video 4

Not at all Confident	1	2	3	4	5	6	7	Extremely Confident
----------------------	---	---	---	---	---	---	---	---------------------

6. Overall, how entertaining were the 4 videos?

BORING	-3	-2	-1	0	+1	+2	+3	FUNNY
---------------	----	----	----	---	----	----	----	--------------

7. Please answer the following:

I paid very careful attention to the videos when they were being played.

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
--------------------------	---	---	---	---	---	---	---	-----------------------

I can remember lots of detail in the videos.

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
--------------------------	---	---	---	---	---	---	---	-----------------------

8. What is your gender?

Male ☐

Female ☐

9. Without looking back at the previous page, what is your **BEST ESTIMATE** for how long you believed **all four videos** lasted excluding the short breaks between the videos?

My **BEST ESIMATE** for how long all four videos took is:

_____ minutes and _____ seconds.

10. Without looking back, how many WOMEN were in the first video, 'Monkeys in Suits'?

0 ☐ 1 ☐ or 3 ☐ 4 or more ☐

That completes the survey. Thank you very much for your help!

APPENDIX 3

**Research Project:
People's judgements about various stimuli**

AX0

BUHREC Protocol number: RO-936

Research Investigators and Contact Details:

Sonia Vilches-Montero

PhD Student. Faculty of Business, Technology and Sustainable Development

Bond University, Gold Coast. QLD 4229

Telephone Number: 07-5595 2206

Email Address: svilches@bond.edu.au

Professor Mark Spence

Faculty of Business, Technology and Sustainable Development

Bond University, Gold Coast. QLD 4229

Telephone Number: 07-5595 2276

Email Address: mspence@bond.edu.au

Explanatory Statement:

Thanks for participating in this study. The purpose of this research is to get your opinions on a series of issues. Participation in the study will take approximately 30 minutes and is entirely voluntary. You are not obliged to participate and you can withdraw at any time without penalty or explanation.

Your responses will be kept anonymous. Your name is required only for you to receive course credit for completing the questionnaire. When you turn in the questionnaire, **please separate this page from the rest of the questionnaire** so that your name will never be connected to your responses. All data will be stored securely for five years, in accordance to Bond ethical guidelines.

Should you have any complaints concerning the manner in which the research is conducted, please do not hesitate to contact Bond University Research Ethics Committee, quoting protocol number RO-936:

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Bond University Human Research Ethics Committee

Bond University Research and Consultancy Services

Level 2, Central Building

Bond University QLD 4229

Telephone (07) 5595 4194 Fax (07) 5595 1120

Email: buhrec@bond.edu.au

Once again, thanks for your help.

Sincerely,

Sonia Vilches-Montero

Dr. Mark Spence

Your name is: _____ (this is collected so that you may receive course credit)

Instructions

You are going to be asked to complete a series of questions on a range of topics, including reactions to videos, puzzle solving, food consumption, and even credit card usage. We are interested in your honest opinion. *Please take your time and think carefully about the questions.*

Thanks in advance for your assistance!

You are going to see a series of four videos. They relate to daily-life episodes that you might watch or experience during a normal day. After watching the videos you will be asked some questions related to their content. *Please relax and enjoy.*

Do not turn the page until you have seen all of the video-tapes. Do not proceed until you are asked. Thank you.

(Start playing videos)

This next series of questions has to do with snack food, specifically cakes. There are no right or wrong answers; we just want your honest opinion.

A convenience food manufacturer is considering introducing individually wrapped, single serve slices of cake to be located in the refrigerator section of grocery stores. *The single serve slices will be positioned in the store next to their already available full sized pies.* The cakes will come in various flavours, such as Double Chocolate Delight and Traditional Sponge Cake. As a student in a marketing class, you know that one of the marketing mix decisions that must be made is to determine the appropriate size for the slice of the cake. On the next page please draw how much cake you would normally eat in one serving – there are no right or wrong answers. You may think that you normally eat more or less than other people – that is not important or relevant. ***Just draw how much you would typically eat.*** Please make your drawing to scale, that is, we need a “life size” drawing. Just show the slice of the cake; do not include the packaging around the slice.

Please turn the page to draw your slice of cake.

In the space below please draw how much cake you would normally eat in one serving – there are no right or wrong answers.

Please turn the page and continue.

Please answer the following questions.

What is your gender?

Male _____ Female _____

Are you currently on a diet?

Yes, I am on a diet _____ No, I am not on a diet _____

Do you like eating cake? Please circle the correct response below.

No, I definitely do not like eating cake 1 2 3 4 5

Yes, I definitely like eating cake

When was the last time you ate some cake, regardless of how much you ate?

Within the last 2 or 3 days _____

Within the last week _____

Sometime this month _____

Over a month ago _____

Please rate how much you agree or disagree with the following statements.

I pay careful attention to my consumption of snack foods, like cake.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am very motivated to control my consumption of cake.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

With respect to eating cake, I have very good self-control.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am very capable of controlling the amount of cake I eat.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am conscious of the amount of cake that I eat.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

With respect to cake, I am willing to restrict my consumption.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

*The following questions pertain to using credit cards. **Whether or not you have a credit card, please answer the questions to the best of your ability.** There are no right or wrong answers; we just want your honest opinion.*

Some people believe that ideally you would not owe anyone money, that is, you would not be in debt. However, few of us achieve this ideal and many people, including some financial advisors, would outright disagree that this is ideal. Assuming that you have a credit card and are willing to carry a balance on your credit card (i.e., you do not pay off the entire balance owed at the end of the month), what do you consider to be an acceptable credit card balance?

An acceptable credit card balance for me is: \$ _____

How many credit cards do you have?

None _____ One card _____ Two or three _____ More
than three cards _____

When was the last time you used your credit card, regardless of how much you charged?

Within the last 2 or 3 days _____
Within the last week _____
Sometime this month _____
Over a month ago _____

Please rate how much you agree or disagree with the following statement.

I pay careful attention to my credit card debt.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am very motivated to control my credit card debt.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

With respect to credit card debt, I have very good self-control.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am very capable of controlling my credit card debt.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

I am conscious of the amount of credit card debt that I have.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

With respect to credit cards, I am willing to restrict my debt.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Please do not turn the page until told to do so. Thank you.

You have **three minutes** to see how many cities you can name starting with a city that begins with the letter A (for example, Adelaide), then B (for example, Beijing), and so forth. Name one city for each letter. If you cannot think of a city that begins with that letter, move on to the next letter. Please do the best you can.

**You may start immediately – the research assistant will tell you
when your three minutes is up.**

Name a city that begins with the letter:

A _____

B _____

C _____

D _____

E _____

F _____

G _____

H _____

I _____

J _____

K _____

L _____

M _____

N _____

O _____

P _____

Q _____

R _____

S _____

How many cities did you name? _____

Please do not turn the page until told to do so. Thank you.

You saw a series of videos. Please answer the questions presented below.

1. How many people were shown in the video “Monkeys in suits”?

2. What company is the sponsor of the car advertisement?

3. What is your **BEST ESTIMATE** for how long you believed **all four videos** lasted excluding the short breaks between the videos?

My **BEST ESIMATE** for how long **all four videos** took is:

_____ minutes and _____ seconds.

4. Overall, how entertaining were the 4 videos?

BORING	-3	-2	-1	0	+1	+2	+3	FUNNY
---------------	----	----	----	---	----	----	----	--------------

5. Please answer the following:

I paid very careful attention to the videos when they were being played.

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
--------------------------	---	---	---	---	---	---	---	-----------------------

I can remember lots of detail in the videos.

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
--------------------------	---	---	---	---	---	---	---	-----------------------

6. What is your gender?

Male ☐

Female ☐

7. Without looking back, how many WOMEN were in the video ‘Monkeys in Suits’?

0 ☐

1 ☐

☐

2 or 3

☐

4 or more

8. Without looking back at the previous page, now you will be asked to estimate the duration of each video in minutes and seconds. To do so, please first provide your BEST ESTIMATE. How long do you think each video lasted? After doing so, we would now like you to put a range about that estimate: what is the shortest time the video could have lasted and what is the longest time? Please try to and keep your range as small as possible, but do your best to make sure the actual length of the video falls between the shortest and longest possible duration.

	BEST ESTIMATE	SHORTEST POSSIBLE DURATION	LONGEST POSSIBLE DURATION
<u>VIDEO 1</u>: Hidden camera			
<u>VIDEO 2</u>: Monkeys in suits			
<u>VIDEO 3</u>: Comedians			
<u>VIDEO 4</u>: Car Advertising			

9. With respect to the time estimates you provided above, how confident are you that the shortest and longest durations that you provided actually include the true duration of the video?

Video 1

Not at all	1	2	3	4	5	6	7	Extremely Confident
------------	---	---	---	---	---	---	---	---------------------

Video 2

Not at all	1	2	3	4	5	6	7	Extremely Confident
------------	---	---	---	---	---	---	---	---------------------

Video 3

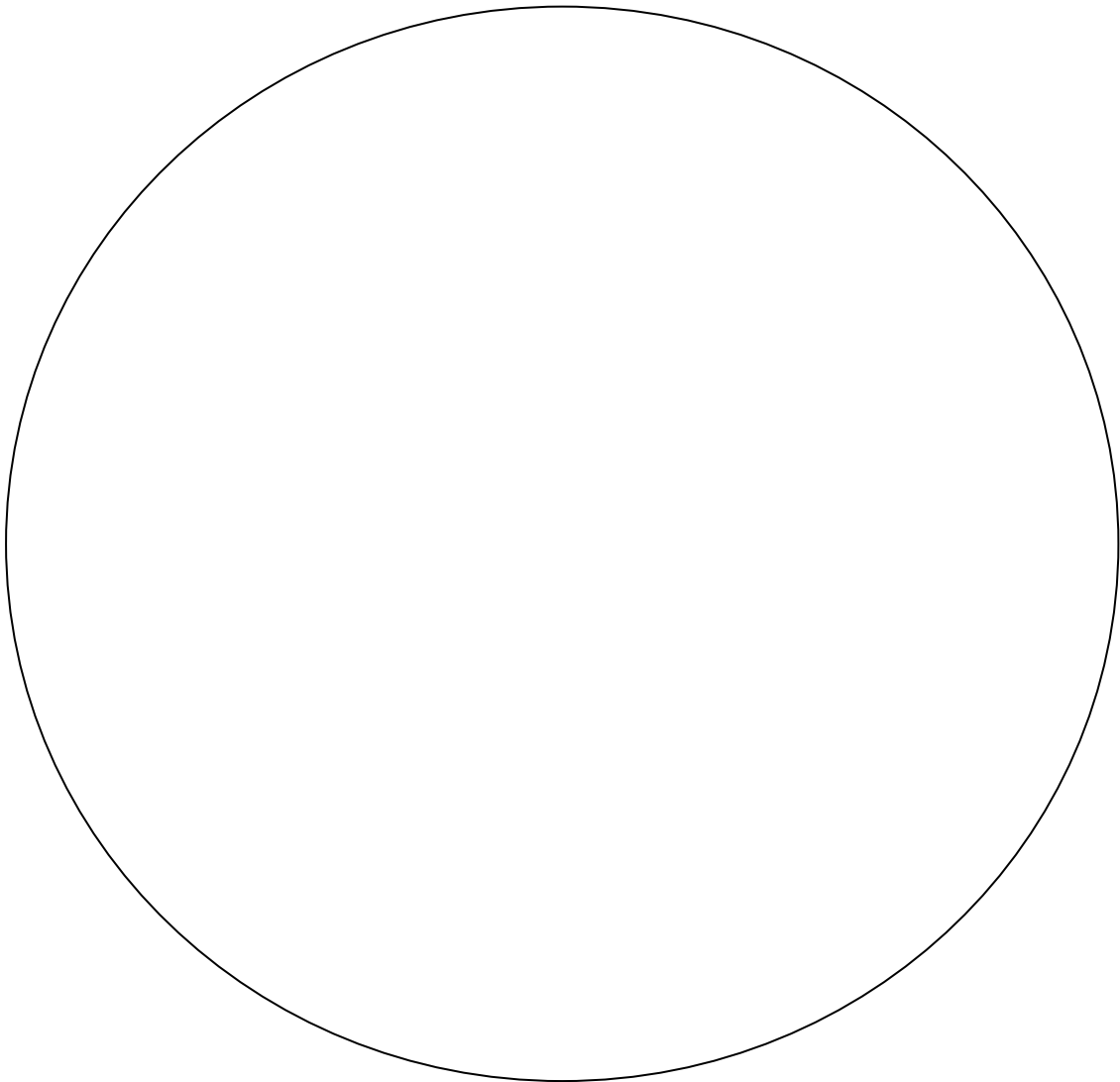
Not at all	1	2	3	4	5	6	7	Extremely Confident
------------	---	---	---	---	---	---	---	---------------------

Video 4

Not at all	1	2	3	4	5	6	7	Extremely Confident
------------	---	---	---	---	---	---	---	---------------------

Earlier we mentioned that a cake company was planning on expanding their product line. Please imagine that the circle on the next page represents one of the whole cakes the company already sells and that it is drawn to scale. Given the whole cake shown below, if this were a real cake, do you think you would like to eat some of it? If NO, please turn the page and continue.

If YES, on the picture over the page please indicate by shading in *how much of the cake you would consume if you could*. There is no right or wrong answer; we just want your honest opinion:



On the previous page you indicated you would **not** consume any of the cake. Out of the reasons shown below, which ones best explain why you decided not to have any cake. Check all that apply.

____ I am not hungry right now

____ I do not like cake

____ The cake offered was too big

____ The cake offered was not big enough

____ I know I really shouldn't eat any cake

____ If I have some cake, I am likely to eat more cake than I should

____ Other reason: please explain below

Please turn the page and continue.

Please imagine that you have received an offer for a credit card that has no annual or sign-up fees. In the promotion material they are required to include material from the Australian Banking Council (ABC). The ABC, an independent government agency, ranked the card in the *bottom 10% of credit cards*: there are hidden charges, interest rates are high, and users cannot earn awards points. This does not mean the ABC is against your accepting the credit card; that is your choice. Would you sign up to receive the card? **If NO, please turn the page and continue.**

If YES, in light of the credit limit on this card, what do you consider to be an acceptable credit card balance?

An acceptable credit card balance for me is: \$_____

Thank you very much! That completes the survey.

We appreciate your assistance.

APPENDIX 4
